SCIENCE

22 July 1960

Vol. 132, No. 3421

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

SCIENCE is published weekly by the AAAS, 1515 Massachusetts Ave., NW, Washington 5, D.C. Second-class postage paid at Washington, D.C., and additional mailing office. Annual subscriptions: $8.50; foreign postage, $1.50; Canadian postage, 75¢.


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22 July 1960, Volume 132, Number 3421

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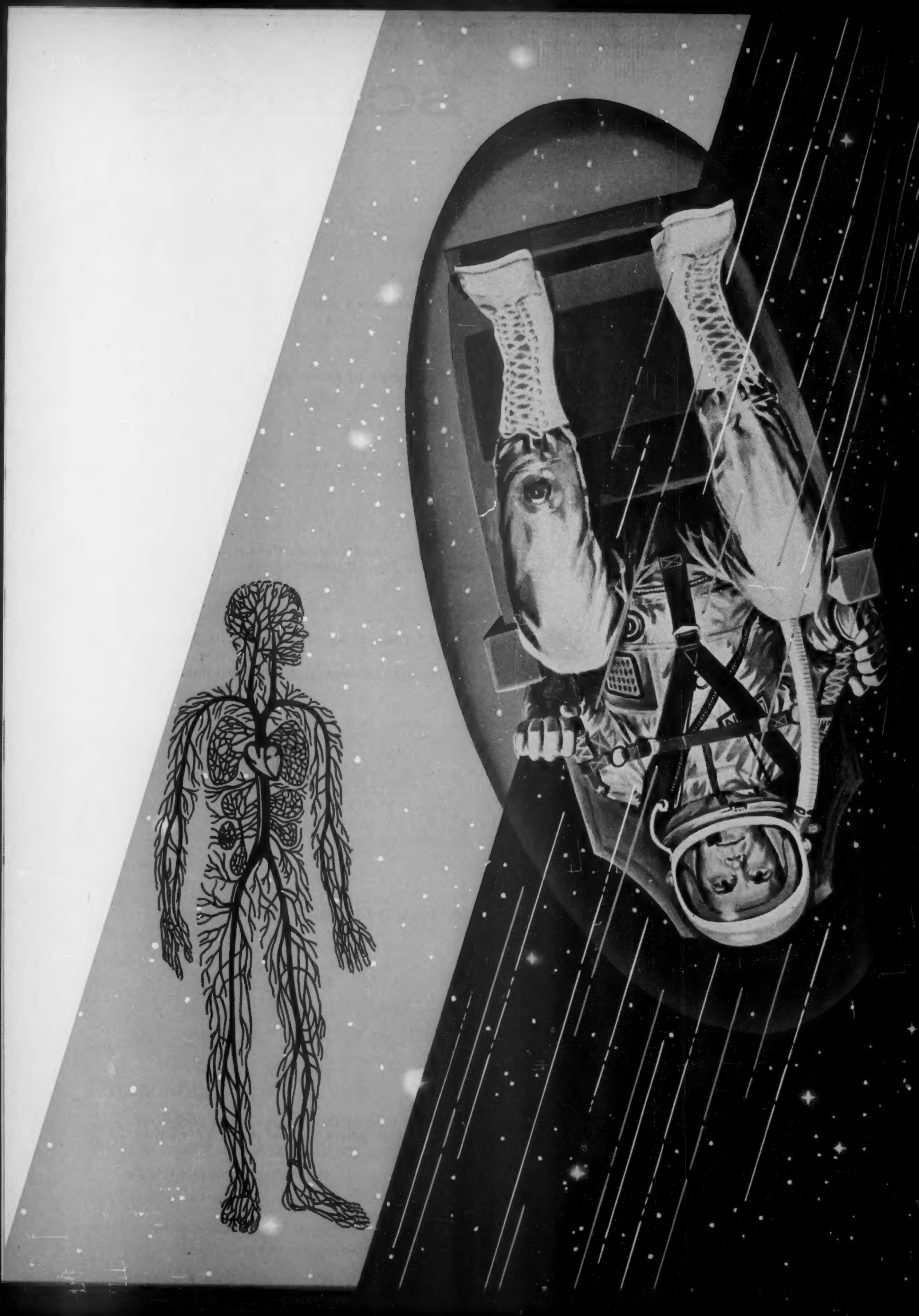
Cover Air photo of Meteor Crater, Arizona, and the Canyon Diablo Area where coesite has been found by scientists of the U.S. Geological Survey in the course of studying specimens of sheared Coconino sandstone. See page 220. [John S. Shelton, Claremont, Calif.]



Pilâtre de Rozier and Marquis d'Arlandes (November 21, 1783), using a Montgolfier balloon, were the first to leave the earth to test man's physiologic reactions. This experiment was the forerunner of intensive Space Medicine studies of today.

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There is a relatively narrow zone above the surface of the earth in which man's physiologic mechanism can function. Hence the unrelenting search by Lockheed scientists into many aspects of Space Medicine.

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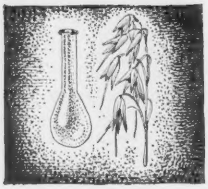
IT HAPPENED THIS MONTH...

a glance at yesterday in relation to today



IN JULY—(1922)—the Journal of Biochemistry (Tokyo) reports the isolation and analysis of the prolamin of *Hato-mugi* (Coix lacryma L.). Hato-mugi is an Asiatic species of grass with large seeds called "Job's Tears," which are often strung as beads to pacify teething infants. Results indicate that it contains glutamic acid, leucine, tyrosine and the basic amino acids, arginine, histidine, and lysine, and resembles the prolamin of oats.[1]

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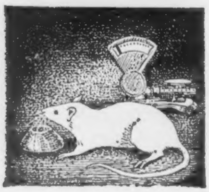

IN JULY—(1929)—Cowgill discusses the physiology of the substance hitherto called "vitamin B."[2] This has recently been shown to consist of at least two physiologically-active factors. One is unstable at high temperatures and is effective in preventing and curing beriberi; the other thermostable component is required along with the antineuritic factor for promoting growth and is probably effective in preventing and curing pellagra.

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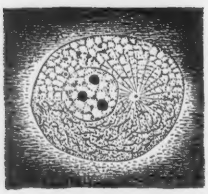

IN JULY—(1959)—discussing the synthesis of organic compounds on the primitive earth, Stanley Miller and Harold Urey state: "The major problems remaining for an understanding of the origin of life are (i) the synthesis of peptides, (ii) the synthesis of purines and pyrimidines, (iii) a mechanism by which 'high-energy' phosphate or other types of bonds could be synthesized continuously, (iv) the synthesis of nucleotides and polynucleotides, (v) the synthesis of polypeptides with catalytic activity (enzymes), and (vi) the development of polynucleotides and the associated enzymes which are capable of self-duplication."[3]

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1. Hattori, G. and Komatsu, S.: The prolamin of Coix lacryma L. J. Biochem. *1*:365 (July) 1922. 2. Cowgill, G. R.: Recent studies in the physiology of vitamin B. Yale J. Biol. & Med. *1*:353 (July) 1929. 3. Miller, S. L. and Urey, H. C.: Organic compound synthesis on the primitive earth. Science *130*:245 (July 31) 1959.

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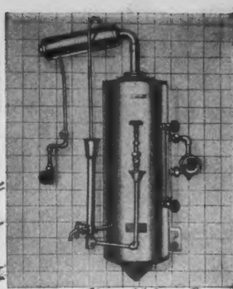

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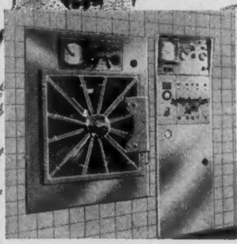

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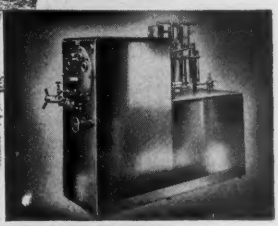

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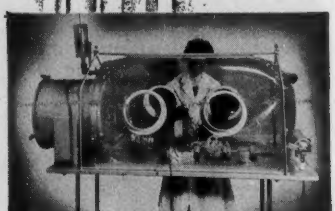

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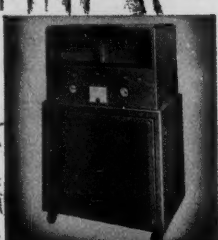

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3. On "AAAS Day," the three broad, interdisciplinary symposia—Plasma: Fourth State of Matter; Life under Extreme Conditions; and Urban Renewal and Development, arranged by AAAS Sections jointly.
4. The Special Sessions: AAAS Presidential Address and Reception; Joint Address of Sigma Xi and Phi Beta Kappa; the Tau Beta Pi Address; National Geographic Society Illustrated Lecture; and the first George Sarton Memorial Address by Rene Dubos.
5. The programs of all 18 AAAS Sections (specialized symposia and contributed papers).
6. The programs of the national meetings of the American Astronomical Society, American Nature Study Society, American Society of Zoologists, History of Science Society, National Association of Biology Teachers, Scientific Research Society of America, Sigma Delta Epsilon, Society for General Systems Research, Society for the Study of Evolution, Society for the History of Technology, Society of Systematic Zoology, and the Society of the Sigma Xi.
7. The multi-sessioned special programs of the American Association of Clinical Chemists, American Astronautical Society, American Geophysical Union, American Physiological Society, American Psychiatric Association, American Society of Criminology, Association of American Geographers, Ecological Society of America, Mycological Society of America, National Science Teachers Association, New York Academy of Sciences—and still others, a total of some 90 participating organizations.
8. The four-session program of the Conference on Scientific Communication: The Sciences in Communist China, cosponsored by the AAAS, NSF, and ten societies.
9. The sessions of the Academy Conference, the Conference on Scientific Manpower, and the conference of the American Council on Women in Science.
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For a list of the headquarters of each participating society and section, see page 230, *Science*, 22 July. Both the Commodore and the Biltmore are AAAS headquarters hotels.

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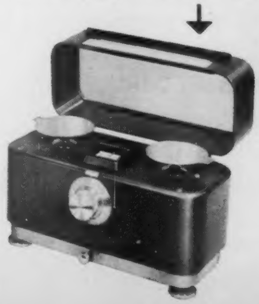

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Additional card on page 241

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22 July 1960, Volume 132, Number 3421

SCIENCE

SCIENCE, which is now combined with THE SCIENTIFIC MONTHLY, is published each Friday by the American Association for the Advancement of Science at National Publishing Company, Washington, D.C. The joint journal is published in the SCIENCE format. SCIENCE is indexed in the *Reader's Guide to Periodical Literature*.

Editorial and personnel-placement correspondence should be addressed to SCIENCE, 1515 Massachusetts Ave., NW, Washington 5, D.C. Manuscripts should be typed with double spacing and submitted in duplicate. The AAAS assumes no responsibility for the safety of manuscripts or for the opinions expressed by contributors. For detailed suggestions on the preparation of manuscripts and illustrations, see *Science* **125**, 16 (4 Jan. 1957).

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Is There Underinvestment in Education?

Belief is widespread that we are not spending enough money on college education in terms of our needs for economic growth, but little systematic research has been done on education as a form of investment. As part of a study for the National Bureau of Economic Research, Gary S. Becker, of Columbia University, has now compared the financial return from a college education with the return from other kinds of investments. The full report is still to be published, but to judge from a preliminary account that appeared in the May issue of the *American Economic Review*, the results will challenge one of our more treasured beliefs. So far as the return to the person getting the education is concerned, Becker finds no evidence for underinvestment. The average return to college graduates is about the same as the average return to business capital.

Although the preliminary account gives few details of the computation, there is some discussion of the operations performed. The return from a college education is calculated on the basis of total college costs, not just costs to the student and his family. The income of college graduates, as measured against the income of persons whose education ended at a lower level, is adjusted for such factors as differences in ability. And the study is limited to men, although Becker does suggest that even for those women who expect to do little work outside the home there may be sound economic reasons for going to college. Women who go to college probably secure husbands with higher incomes than women who do not.

Economists distinguish between direct and external returns, and in the analysis of education this distinction corresponds to that between the effect of a college education on the incomes of persons getting the education and the effect on the incomes of others. The study is concerned only with direct returns, but those arguing that too little is being spent on education can note, for example, that developments in atomic physics are necessary for atomic power and that most atomic physicists are college graduates. To this argument Becker replies that it is easier to give examples of the contribution of science and technology to economic growth than it is to assess the contribution quantitatively or to compare it to the external returns from business capital. In fact, he intimates that, generally speaking, economists know very little about external returns. Consequently, since direct returns indicate no great underinvestment, if the existence of underinvestment is to be argued, the argument must lie in the little explored area of external returns.

The American economy, not to mention American military technology, of course, needs scientists and engineers. To this particular point Becker replies that the special demand for technical experts can be met with a comparatively small increase in the total expenditures on college education. Investment in scientific training is important, but by itself such training is not so very expensive.

To be sure, college attendance offers other rewards besides economic gain; it offers personal enlightenment and preparation for effective citizenship. But restriction of the study to economic considerations no more reflects on these other objectives than it lessens the value of the study as it bears on strictly economic arguments. One comment that has been directed against the study from the economic side is that even if the return to college graduates is the same as the return to business capital, this finding does not necessarily imply that there is no underinvestment in education. The finding might just as well imply that college graduates are underpaid or, to strike an anti-inflationary note, that everyone else is overpaid.—J.T.

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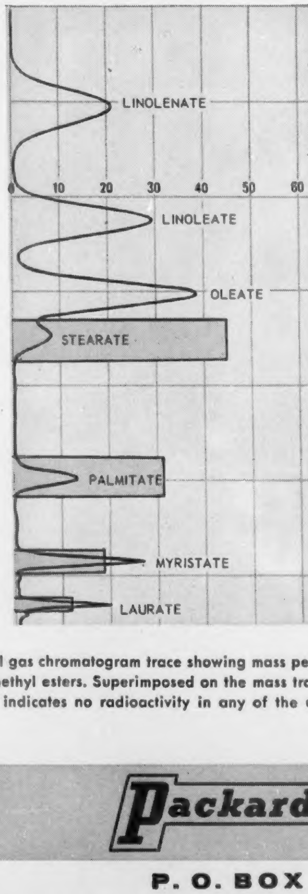

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22 July 1960, Volume 132, Number 3421 SCIENCE

CURRENT PROBLEMS IN RESEARCH

Biophysics of Bird Flight

The very low drag of nature's aircraft, birds, sets a goal for man in his striving for efficient aircraft.

August Raspet

There is no doubt that modern mechanical flight owes its inspiration to observations of birds in flight by early philosophers and scientists as well as by interested laymen. The earliest living "flying machine" is dated about 150 million years ago. This was the pterodactyl of geologic times. In contrast, man-made flying machines are only 57 years old. You can see from this contrast of eras that we may look for new knowledge of flight from a study of this age-old concept of bird flight.

In Greek mythology, the story of Daedalus and Icarus is well known. Daedalus designed and built, supposedly, two flying machines, covered with feathers, using a structure of wax to support them. This was really a mythical imitation of bird flight. There was no application of real knowledge of the mechanism of bird flight, merely an imitation, in form, but not in function. But, of course, not having this knowledge, we, even today, cannot duplicate bird flight in the sense of straight imitation on a scale such that a man can fly as a bird does, by his own muscle power.

The first known flying machine constructed on bird-flight concepts was da Vinci's well-known invention. About 1505, da Vinci test-flew this machine, using a test pilot, as is common practice today. The results are indicated in da Vinci's notebooks by the fact that after this test flight there was no more mention of flying. There is rumor that the test pilot broke his leg. The test pilot, in this case, was one of da Vinci's household servants (Fig. 1).

It was Lilienthal (*1*) who also imitated bird flight, even to the point of using such small stabilizing tail surfaces that his machine was only marginally stable. But we must remember that it was also Lilienthal who, by this bird imitation, proved Newton, Kirchhoff, and Helmholtz to be wrong in their concept that lift is generated by a downward deflection of the air, simply as a reflection phenomena, and in disregarding entirely the suction on the upper surface. For his failure to understand that birds possess automatic stability due to instinctive reflexes, in addition to that inherent in their geometry, Lilienthal paid with his life.

The realm of bird flight can be clearly divided into two aspects: that on motionless wings, which is soaring, and that on flapping wings, which is really the working part of flight. The latter is used in take-off and in climbing to altitude, even by soaring birds. It is used as a principal mode of flight by the nonsoaring birds. The soaring phase of flight, or the flight on motionless wings, was divided by Lord Rayleigh in 1883 (*2*) into three separate categories: (i) Flight in which the path is not horizontal—in other words, gliding; (ii) flight in an air mass which has a vertical component—that is, static soaring; and (iii) flight in an air mass which is not uniform in velocity. The latter is, in the strict sense, dynamic soaring. Evidently, a good understanding of the first phase, the motionless wing phase, would contribute much to an understanding of the biophysics of bird flight. The second kind of flight, much more complicated (flapping flight), has been theoretically studied, but very little experimental work has been done to support the various theories. It is the purpose of this article to take up in detail the aerodynamics of a bird's wing—in particular, that of motionless wing flight.

Wind-Tunnel Experiments

When we consider the various tools available to us for studying flight in general, we are apt to resort to the one which has been so useful in helping man to fly—namely, the wind tunnel. It was a wind tunnel which helped the Wright brothers to arrive at proper airfoil sections, and the wind tunnel is still used today for subsonic, transonic, supersonic, and hypersonic flow studies. It will be interesting, therefore, to look at some results from wind-tunnel work on the measurements of bird aerodynamics and compare these results with some data obtained in flight. From this, we can determine the validity of the wind tunnel in bird-flight work. In Fig. 2 is shown a velocity polar of a laughing gull, computed from data measured in the wind tunnel and data measured in flight. The velocity polar is clearly seen to consist merely of a plot of sinking speed, which is really a measure of the energy loss in flight, versus the forward velocity of flight. Actually, this is not a polar, but the terminology is that which is used in aviation. It should be mentioned that the laughing gull measured in the wind tunnel (*3*) was not actually a feathered bird, but rather a clay model sculptured by an artist. The tunnel, however, possessed a rather low turbulence and provided an environment quite representative of that which one might find in the atmosphere. On comparing the sinking speed obtained from the wind-tunnel measurements, one sees that the sinking speed of the clay model is a little more than double that of the actual bird

The author, at the time of his death on 27 April, was head of the aerophysics department of the Engineering and Industrial Research Station, Mississippi State University, State College.

Fig. 1. Artist's conception of Leonardo da Vinci's flying machine in flight. Note that da Vinci, knowing human anatomy as he did, at least tried to harness the powerful thigh muscles, whereas many other experimenters used only the arm muscles. [From a painting by Robert Riggs, courtesy of International Business Machines Corp.]

measured in flight at the speed of 30 miles per hour. The flight measurement consisted of a very simple comparison of the flight of the gull, while soaring on a ridge on Long Island, relative to that of a sailplane. The pilot in the sailplane was able to adjust his speed to follow the bird exactly, and at this particular forward speed, the bird and the sailplane flew back and forth on a ridge for about 2 hours, neither outclimbing the other.

This is proof that their sinking speeds at this forward speed were identical. It is just this concept of comparison flying which I will discuss in connection with some measurements of the black buzzard. The technique was developed to a higher state and used to get the complete measurement of the drag of a bird over the speed range of its flight in the gliding phase.

However, in order to determine the nature of the aerodynamics of birds in terms of the known parameters used in aeronautics, we must refer the drag to a nondimensional drag coefficient C_D:

$$C_D = \frac{D}{\frac{1}{2}\rho V^2 S},$$

where D is the drag in force units, ρ is the air density, V is the velocity of flight, and S is the wing area, including that intercepted by the body.

In a similar matter we define the lift coefficient C_L,

$$C_L = \frac{L}{\frac{1}{2}\rho V^2 S},$$

where L is the lift in force units. If, now, the velocity polar of Fig. 2 is transformed into a curve of C_L^2 versus C_D, we obtain Fig. 3. The reason for plotting against the square of the lift coefficient is quite evident when one sees that the induced drag coefficient—that is, the drag due to lift—is a function of the square of the lift coefficient:

$$C_{D_i} = \frac{C_L^2}{AR_e},$$

where AR_e is the effective aspect ratio:

$$AR_e = \frac{b^2}{S}e,$$

b being the span and e the span efficiency factor.

What one sees from the linearized drag polar of Fig. 3, is that the flight-measured point lies on an extension of the linear portion of the wind-tunnel measurements. This indicates that the wind-tunnel results must be in error below a lift coefficient equal to 0.8.

Obviously, the clay model was not representative of a feathered bird in flight. In fact, it is doubtful that even a feathered model could accurately duplicate the aerodynamic properties ascribable to the elasticity and mobility of the feathers on a live bird.

However, one can admire the finesse with which nature has designed her flying machines in observing the neat intersection of wing and body in Fig. 4, which shows a drawing of the laughing gull, taken from Feldmann's paper. In this drawing, the very pointed tips of the soaring birds of the sea are conspicuous. In Fig. 5 the distinctly different tips of soaring land birds are shown. The question then arises, "What is the function of this pointed tip as contrasted with the slotted wing tip of soaring land birds?"

It has been suggested that since soaring land birds must land and take off from trees, a large span would be a handicap. Therefore, the slotted wing tip serves to diffuse the vortex flow at the tip, permitting the soaring land bird to attain good performance in spite of limited aspect ratio. The sea bird on the other hand is not limited by its environment with respect to aspect ratio.

However, an analytic investigation by Newman (*4*) disputes the premise that the slotted tip can reduce the induced drag over that of a solid tip. We are then left without a logical explanation for the slotted tip of soaring land birds. Wind-tunnel tests with smoke streams and a live bird trained to fly in a tunnel could add to our knowledge of this important distinction between soaring land birds and soaring sea birds.

In order to duplicate this complicated model, the live bird, one might freeze a bird and then test it in a wind tunnel. This was done at the Washington Naval Shipyard wind tunnel some years ago, but again we have the criticism that a change occurs in the elasticity of the support of the feathers, as well as in the feathers themselves, in the process of freezing the bird. Another criticism of the frozen-bird technique lies in the fact that the bird uses its wing muscles even in gliding flight as a means of control. This is necessary, since the bird possesses little or no inherent aerodynamic stability except possibly along the body axis in roll. In yaw and, to a lesser extent, in pitch, the bird with fixed geometry appears to have neutral or negative stability. In

other words, the flight of a bird is stabilized by minute involuntary control deflections. This is similar to the process of walking in man, in his erect posture.

Another feature of the bird's aerodynamics is the porosity of the feathers. Whether this feature plays an important role in the aerodynamics of the bird or not has not yet been established. Victor Loughheed is reported to have measured the porosity of the bird's feathers, finding the porosity ten times greater in the downward direction than in the direction up through the wing feathers.

In some birds, in addition to the usual features of the feathers—flexibility, mobility, and porosity—there is also a toothed leading edge. This is true particularly in owls, which must fly silently and stealthily upon their prey in the field. Graham (*5*) believes that this toothed leading edge reduces the velocity of the flow over the wing. This may be so, but if there is too much loss of velocity in the flow near the leading edge, a wing with a toothed leading edge will not develop as high a lift as one without this edge. This means that the bird with a toothed leading edge to its wing would have to fly faster than one with a smooth-edged wing. Thus, the noise would not be essentially reduced. Yet the owl does fly silently.

Perhaps we might speculate on the function of the toothed leading edge by drawing on an analogy. If a piece of wire of cylindrical form about 3 millimeters in diameter and 1 meter long is swung through the air in a rotating motion similar to that of a propeller, a distinct tone similar to that of a singing telephone wire is emitted. Now, if instead of a single cylindrical wire, two wires of 1.5-millimeter diameter are twisted together in a tight spiral and then spun, the noise level is much lower in intensity and in frequency. In fact, only the free end emits a noise.

From this experiment we might say that the toothed leading edge behaves in the same way that the twisted wire does—that is, in a manner to reduce the vortex noise emitted by the flow leaving the wing. However, remember that this is merely a hypothesis and not absolute proof of the function of the toothed leading edge of the wings of owls.

Since the bird possesses little or no inherent stability in pitch, the question of the function of the tail arises. In general, the tail is used as a landing aid similar to the flap on an airplane. Photographs show clearly that the tail

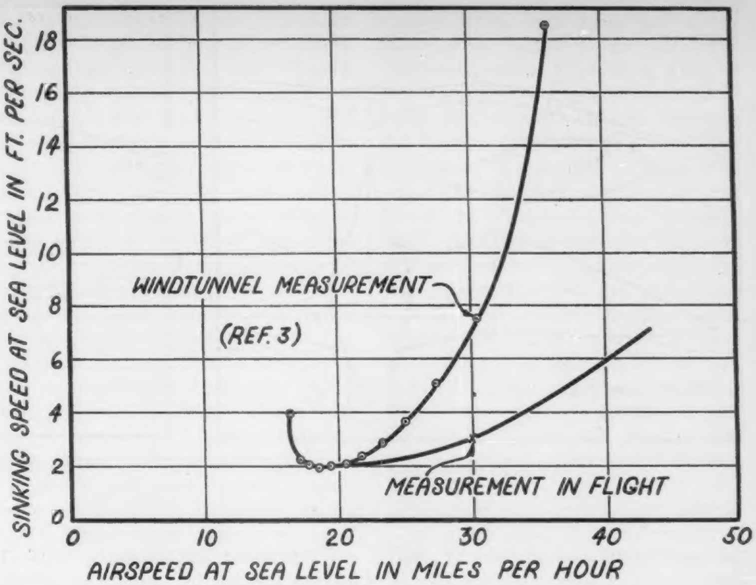


Fig. 2. Velocity polar of a laughing gull.

of most birds fans out to increase the lifting area just before touchdown and is folded during gliding flight.

At the same time, during the landing, it will be seen that the alula or false feather, representing the thumb of our hand, opens in order to increase the lifting power of the wing. This same alula is used as a lateral control for initiating rapid turns.

The reader may wish to try a simple experiment which illustrates the function of the alula. If, while driving at about 50 miles per hour, one puts his hand out of a car window with the hand cupped slightly and at a positive angle to the wind, he can, by simply moving his thumb up or down, cause a large change in the lifting force his arm experiences. This is how the bird applies control in roll about his longitudinal body axis.

Having seen, in Fig. 2, that windtunnel tests of bird flight are fraught with possible large errors, we are forced to look for new means of determining

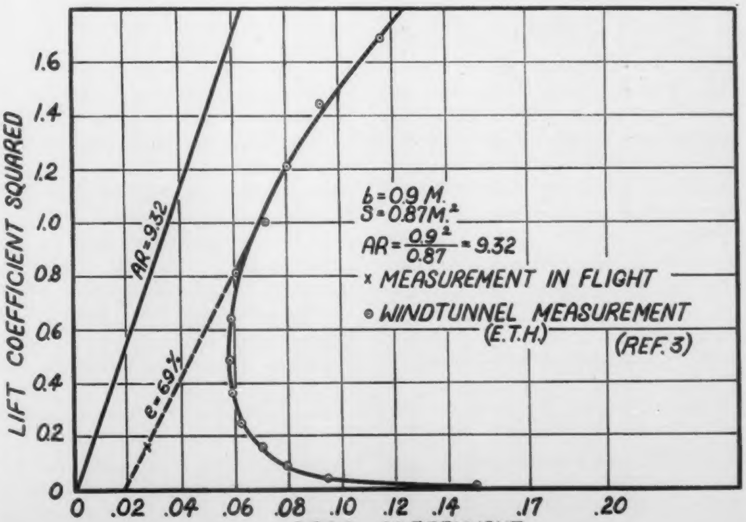
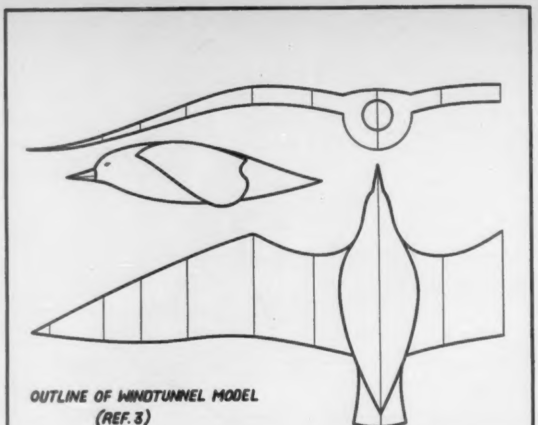


Fig. 3. Linearized drag polar of a laughing gull.



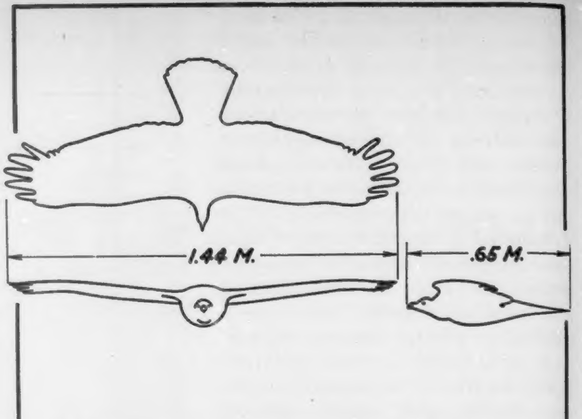


Fig. 4 (left). Three views of a laughing gull. Fig. 5 (right). Three views of the black buzzard.

the aerodynamic properties of bird flight.

From about 1890 to 1900, S. P. Langley, then director of the Smithsonian Institution, attempted to determine the flight characteristics of buzzards in the neighborhood of Washington, D.C., by photographing the birds with two telephoto cameras, arranged stereoscopically. Such a technique would certainly have determined the geometry of the bird while the bird was airborne, but it would not have determined the energy losses, unless a time-lapse method had been used, together with triangulation by double theodolite methods.

In view of the difficulty of studying the flight of wild birds from the ground, George Carter and I, in 1945, started an experiment in which a young wild buzzard was to be trained to carry a small recording barograph and anemograph attached to its belly. The bird was trained successfully to do its job and to carry a mock-up of the recording instrument, which was to weigh 30 grams and have dimensions of 2 by 3 by 5 centimeters. However, before the actual measurements could be made, the bird died of an intestinal stoppage. Our success in training this bird was due to the skill and understanding of George Carter.

Had this experiment been successful, it would have yielded the sinking speed as a function of air speed—that is, the speed polar, similar to that in Fig. 2. But for a soaring land bird we would need to observe the mode in which the bird is flying in order to delineate the function of the variable geometry of the slotted wing tip.

Furthermore, the success achieved in training this one bird by Carter clearly supports his contention that it would be possible to train live birds to fly in a wind tunnel whose axis could be inclined to the horizon. Thus, one could force the bird to fly at different gliding angles and at different air speeds, simply by inclining the tunnel and varying the air speed so that the bird would remain motionless in the throat of the tunnel. With this method, one could delineate the function of the slotted wing tip as well as derive drag polars for various changes in geometry which the bird would be compelled to make in order to stay in the tunnel.

Comparison-Flight Studies

Since the technique of using trained birds was so dependent on the training of the birds and so time-consuming, the comparison method of flying with birds in a sailplane was developed in 1949 (6) as a refinement of the simple one-point comparison test made on the laughing gull, as represented in Fig. 2.

In the comparison method for determining the speed polar and consequently the drag polar of a bird in free and natural flight, a sailplane of low sinking speed and low forward speed capability is needed. In addition, the sailplane must be highly maneuverable, since the pilot must follow birds that can turn with extreme rapidity.

Figure 6 shows a sailplane rigged for bird-flight research. A small radio transmitter and receiver are carried, for transmitting data to a data recorder on the ground. The telephoto camera on the nose of the sailplane is used to record the geometry of the bird. However, the results obtained with this camera were not helpful, because it was not possible to determine the orientation of the tip feathers from the nonstereoscopic photographs.

In making these measurements, the sailplane was launched either by a ground tow behind an automobile on a long runway or by an airplane tow. When the sailplane reached an altitude where upcurrents were strong enough to support it, the pilot would release and soar in a good upcurrent. Ground observers would scan the skies for buzzards, and when one was found, would direct the pilot to the buzzard by radio. When the pilot located the bird he would descend to the altitude of the bird and then follow it, staying no more than 5 to 10 meters behind it. At 30-second intervals, the pilot would report the air speed at which he and the bird were flying and the altitude of the bird above the horizon, measured in wing spans.

Subsequently plots of the altitude of the bird against time yielded, from the slope of this plot, the difference in sinking speed between the bird and the sailplane. Then, by measuring carefully the sinking speed of the sailplane in the still air of the morning at various air speeds, one can obtain the speed polar of the sailplane. Adding to this polar the differences in sinking speed between the bird and the sailplane, we arrive at the speed polar of the bird (Fig. 7).

In this illustration, the two modes of gliding flight yield two different speed polars for the bird. In the soaring mode the bird flies with open tip slots, while

in the gliding mode it flies usually on a long descent at relatively high speeds, with tip slots closed. Also, in the latter mode the bird introduces an M-shaped sweepback, whereas in the soaring mode there is a pronounced forward sweep of the wing. Figure 5 shows the black buzzard (*Coragyps atratus*) in its soaring mode.

Returning to Fig. 7, we see that at a speed of 17 meters per second the speed polars cross. Above this speed the bird chooses the gliding phase, for when the bird is gliding its sinking speed is considerably lower than it is with the tip feathers opened. Below 17 meters per second the bird finds that it can reduce its sinking speed by opening the tip slots, and can thereby increase its glide ratio (L/D). The glide-ratio curves represent the distance the bird can fly for each unit loss of altitude. In other words, the black buzzard is capable of gliding 23 miles in still air from an altitude of 1 mile at its best glide ratio. This remarkable feat is possible at a relatively slow forward speed of 15 meters per second with tip slots open.

An interesting biophysical constant can be derived from the velocity polar of Fig. 7. If we wish to determine the minimum power required for the bird to maintain level flight, we take the product of the minimum sinking speed of 0.62 meters per second and the weight of the bird. This yields the rate of loss of potential energy which must be compensated by muscle power for the black buzzard in level flapping flight. The minimum power required to maintain level flight is 0.019 horsepower. For this bird, which weighs 2.3 kilograms, this results in a power loading of 122 kilograms per horsepower. A rough value for the capability of muscles to put out continuous power is 1 horsepower for 50 kilograms of muscle.

The value of 122 kilograms per horsepower then implies that flight muscles must constitute 42 percent of the bird's weight. If, then, flapping muscles do not constitute at least 42 percent of the black buzzard's weight, we can conclude that this buzzard could not maintain continuous level flight without help either from upcurrents or from dynamic soaring, in which energy is extracted from the fluctuations in the wind.

In order to compare the afore-mentioned free-flight method for determining the aerodynamics of a bird in gliding flight with wind-tunnel measurements, the data of Fig. 7 have been transformed into a linearized drag polar (Fig. 8). In this illustration are shown the drag polars of the black buzzard in the two modes of gliding flight and wind-tunnel data for the laughing gull, the cheel (pariah kite), and the Alsatian swift. The same conclusion that was drawn from the single laughing gull measurement is borne out by the complete polars of the black buzzard—namely, wind-tunnel measurements of models of birds cannot yield valid information concerning the aerodynamic properties of birds in natural flight. For this reason, progress in understanding the more difficult phases of flapping flight will only be possible when theory can be supported by flight measurements made under natural conditions. In general, the measurements made in wind tunnels tend to ascribe to the bird much higher energy losses than it actually experiences. For this reason, any biophysical conclusions would lead to absurdities if they are based on wind-tunnel measurements made on model or stuffed birds.

However, the comparison-flight method is subject to some criticism at the present state of the art. Since the measurements with wild birds had to be made in the middle of the day when birds were soaring—that is, in a turbulent environment—one cannot absolutely say that the black buzzard possessed the very low drag coefficient which was measured. We say that either it possesses this low drag coefficient or else it must be utilizing a source of energy which the sailplane was not. The only possible means of extracting such energy from the environment lies in dynamic soaring. However, we do have rather positive evidence that the lowest measured drag values are valid for the high speed points on the speed polars of Fig. 7, since they were obtained near sunset when the air was quite smooth, during a glide to roost of a black buzzard.

Nevertheless, there cannot but be some doubt about the validity of data taken in turbulent air. For this reason, making a measurement during the early hours of the morning when the air is very still suggests itself. For this test, several wild captured buzzards would be carried aloft in a two-seater sailplane. On tow, behind the same towplane, would be the measuring sail-

Fig. 6. Sailplane for research on bird flight.

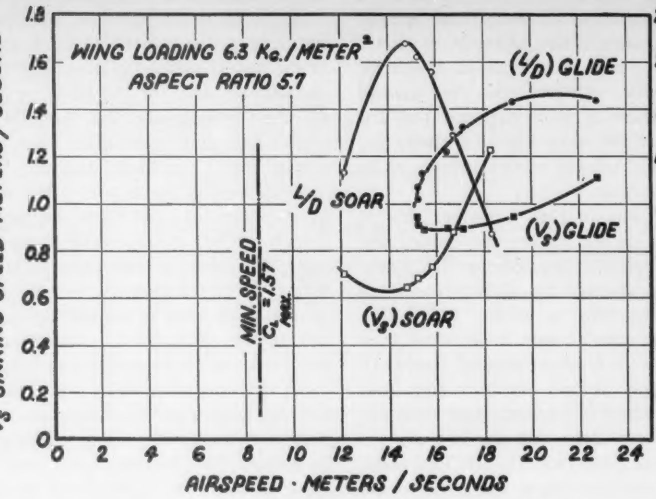


Fig. 7. Velocity polar and glide ratio of a black buzzard.

plane, of light, maneuverable design, fitted with radio communication equipment. After the two sailplanes reach an altitude of 1500 meters, they will be released from the towplane, which will descend to the airport. The bird-carrying two-seater will move ahead of the measuring sail plane, headed toward the airport where the birds have been cooped. On a signal from the measuring sailplane, the bird handler will release a bird from the two-seater by dropping it out in an open-ended bag, to which is attached a line. At the end of the line, the bird will fall out of the bag, head first, and will start gliding toward its coop. Whether every bird will cooperate in this manner is yet to be determined. However, if the birds merely glide in any direction, useful data can be obtained, for the measuring sailplane is capable of landing in any small field and can be disassembled for return to its base by trailer (*6a*).

During the glide of the bird, the measuring sailplane will record data in the manner ascribed for the comparison-flight method.

The precision of this method should be much greater, for, in this case, both the bird and the sailplane will be flying in smooth air, that in which the sailplane has been calibrated.

The results of these measurements in still air should either confirm the measurements given in Fig. 7 or perhaps, under certain flight conditions, especially at the lower speeds with the bird's slotted wing-tips open, reveal a disparity. If the difference is significant and if the sinking speed measurements made in turbulent air are lower than those made in still air, then we must look to the mechanism of dynamic soaring for an explanation. As a matter of fact, the investigation of the nature of this energy extraction will yield valuable information on the little-known science of dynamic soaring, of which some aspects are discussed below.

Bird and Airplane

Up to now, all of our comparisons of bird aerodynamics have been "within the family." The question naturally arises, "How good is the bird compared with modern aircraft?" Obviously, trying to compare a bird cruising at 30 to 60 miles per hour with a supersonic airplane would be absurd. Even if we compare the bird with some of our subsonic airplanes, we still have the problem of scale and speed differences. Fortunately, we can rely on the well-known Reynolds number as a means for eliminating the objection that we are comparing vehicles in different domains of the viscous-flow regime.

In Fig. 9, the drag polar of the black buzzard in its two modes, gliding and soaring, has been transformed into a plot of average skin-friction drag coefficient versus Reynolds number. On the same plot are shown the Blasius curve for pure laminar flow over a flat plate and the von Karman curve for turbulent flow over a flat plate. These two curves provide us a standard over the rather large scale and speed domain covered, from birds to large airplanes.

It should be mentioned that the data for the airplane shown were also obtained in gliding flight, with propellers feathered after the plane had climbed to altitude on its engines. When we look at Fig. 9 we find that the black buzzard's skin friction coefficient is only 30 percent higher than that of the laminar plate, whereas our best man-made flying machine, a sailplane, possesses a skin friction coefficient 330 percent higher than the laminar flat plate flow. And our best-measured air-

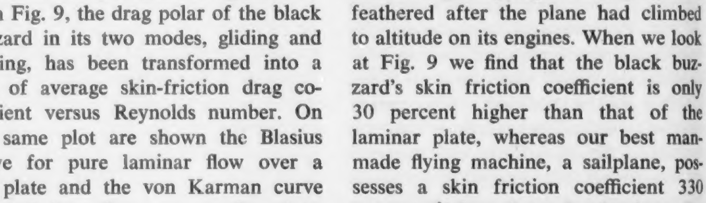


Fig. 8. Linearized drag polar of the black buzzard, laughing gull, Alsatian swift, and cheel.

plane has the poorest showing, having 29 times greater skin friction than the laminar flat plate.

From this curve we can conclude that the many generations of selective breeding have resulted in a flying machine, the bird, which still gives man a goal toward which to strive.

Furthermore, the fact that the high-speed end of the curve of skin friction for the bird came from data points taken in calm air gives some validity to a speculation that the bird must, through the porosity of its feathers, exercise some type of boundary layer control—that is, that there must be some automatic fluid mechanical process in the bird's make-up by which a good portion of the flow over the bird's surface is kept laminar. The difference in porosity measured by Victor Lougheed may be the key to this process.

In fact, on the basis of this speculation, I was inspired to attempt to duplicate the boundary layer control which I suspected the birds were achieving. By making many small holes in a section of a sailplane wing and sucking the boundary layer air into the wing with a fan, I was able to measure drag reductions of the order of 50 percent when even the power required for the suction fan was considered to be a loss (7). Later on, it was also discovered on this sailplane that this same suction could increase the lifting power of the wing. We may thus further speculate that the bird may be utilizing boundary layer control, both for high lift and for low drag.

Recently, a very fascinating discovery was reported by Kramer (*8*)—that there exists an automatic boundary layer control in the skin of the porpoise. Examination of the skin of the porpoise disclosed that the porpoise is completely covered with a hydraulic skin 1/16 inch thick that is elastic and ducted. Kramer was able to duplicate this natural boundary layer control device by selecting a rubber skin of suitable stiffness and by introducing a damping fluid behind the skin. The stiffness was controlled by small rubber stubs. Between the stubs was the damping fluid.

But it is conceivable that nature has solved this problem for birds in a manner that is not analogous to the solution for the porpoise.

The problem of trimming an aircraft for various speeds is particularly vexing on flying-wing aircraft. Since all birds are essentially flying-wing aircraft, it is possible that we can learn a trick or two

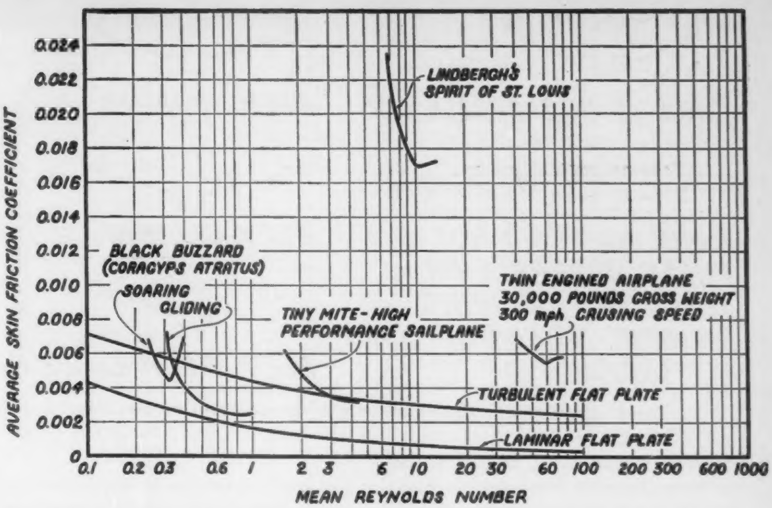


Fig. 9. Skin friction curves plotted against mean Reynolds number for the black buzzard, a high-performance sailplane, and a high-performance twin-engined airplane.

from the way birds apply trimming moments for various flight conditions. We know that the bird's wing is in general fairly highly cambered. Therefore, we can expect large pitching moments. In order to achieve stable flight, these pitching moments must be balanced by aerodynamic moments developed by the tail of a conventional airplane or by twisting and deflected elevators at the wing tips on a swept flying wing.

Let us look at a comparison of a flying-wing sailplane and the black buzzard (Fig. 10). Instead of plotting C_L^2 versus C_D, as we did before for the linearized polar, we have plotted C_L^2/AR versus C_D, which is in actuality a plot of the theoretical induced-drag coefficient versus total-drag coefficient C_D. The purpose in doing this was to be able to derive some information on the induced drag from aircraft of widely different aspect ratios—namely, 5.7 for the bird and 21.8 for the sailplane.

It is immediately apparent that the slope of the curve for the buzzard is much steeper than that for the sailplane. This means that if the two had the same aspect ratio, the bird would outperform the sailplane, especially at

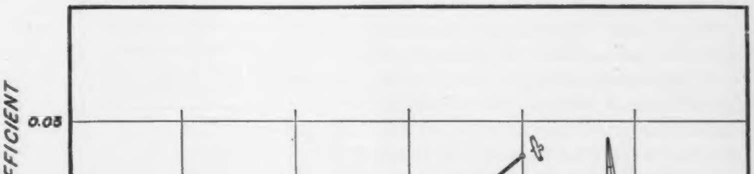


Fig. 10. Comparison of span efficiency factors of the black buzzard and the Horten IV tailless sailplane.

Fig. 11. Wing configurations at various flying speeds for *Otogyps calvus.*

the high lift coefficients used in soaring. In studying the reason for the high induced drag of the Horten IV flying-wing sailplane, we found that the elevators at the trailing edge of the wing caused a severe induced drag, due to the change in the spanwise lift distribution necessary for trimming the sailplane at high angles of attack.

The question is, then, "How does the bird accomplish this trimming without suffering the resultant induced drag rise?" Figure 11, taken from Hankin (9), shows the plan form of a buzzard (*Otogyps calvus*) in various flight modes. At low speeds, the wings are swept forward. In other words, the center of pressure of the wing is moved forward of the center of gravity of the bird. As a result, an upward pitching moment is developed which counterbalances the nose down-pitching moment of the highly cambered wing.

Whether the trimming by means of forward and backward sweep results in a stable configuration in pitch cannot be determined without a knowledge of the camber and the angle of attack distribution of the bird's wing. However, the bird is capable of correcting for instability by means of intuitive sensing and associated reflexes.

The process of trimming to different speeds is clearly seen from Fig. 11. At very high speeds, the tips are swept back by bending the elbow of the wing. This tends to move the center of pressure of the wing farther back, a nose down-pitching moment and trimming for higher speeds thus being achieved.

The foregoing explanation of the control of a bird in pitch is admittedly sketchy. It would, however, be entirely possible to carry out experiments on the control and stability of a bird which had been trained to fly in a tunnel that could be inclined with the horizon so as to force the bird to fly at different glide ratios and speeds. By adding weight to the bird ahead of, or behind, its center of gravity, it would be possible to introduce pitching moments for which the bird would have to compensate with sweep of the wings.

Soaring

So far we have discussed only the aerodynamics of the bird in gliding flight and the bird's stability. Now we will consider the process of gaining energy from the atmosphere—namely, soaring. Static soaring is accomplished by flying in an upward-moving air mass having a higher vertical velocity than the bird's minimum sinking speed. By staying within the confines of such upcurrents, the bird will gain altitude.

One common cause of upcurrents is orographic lifting as the wind passes over a ridge. Birds are capable of soaring on declivities of very small dimensions. However, they also soar on mountain sides, the best example being the soaring of hawks on Hawk Mountain in Pennsylvania.

With a sailplane fitted with a sensitive instrument measuring the rate of climb, a pilot is able to duplicate the bird's feat of soaring on a ridge. In fact, often a sailplane pilot merely needs to follow the bird in order to find the best lift.

Just how the bird measures the vertical velocity and just how it determines which way to turn in order to stay in the upcurrent are questions which we cannot presently answer.

Another source of energy for soaring is that provided by thermal upcurrents. These exist both in hilly and in flat country. A very thorough exposition of the nature of birds soaring on thermal upcurrents is given by Huffaker (*10*). Not only did Huffaker in 1897 clearly describe the bird's thermal soaring but he also indicated that there is good reason to believe that birds have some means for detecting thermal upcurrents at a distance, for they often head directly for a given area and be-

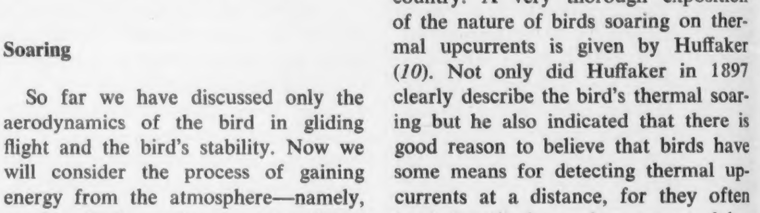


Fig. 12. Modes of soaring of herring gulls, based on temperature increment and wing speed.

gin circling. They inevitably gain altitude.

Some years ago I speculated that the bird must measure in some way the temperature gradient in the horizontal plane and that from this gradient it is able to determine the direction toward the warm upcurrent core. An attempt to do this in a sailplane merely proved that we know too little about the nature of thermal upcurrents to be able to devise instruments for prospecting for the thermal upcurrents (*11*).

Another form of upcurrent, still a thermal upcurrent but over water instead of land, was beautifully studied by Woodcock (*12*), using herring gulls as his indicators of the nature of the upcurrent. In Fig. 12 is shown a plot taken from Woodcock's paper, which delineates the type of thermal upcurrent, a columnar or cylindrical vortex with axis horizontal. This research is a clear example of the careful observation and analysis which should be applied to more of the problems of bird flight.

The third source of energy for soaring is that which Lord Rayleigh described as flight through air which possesses velocity fluctuations. On the basis of this thesis, S. P. Langley (*13*) made a study of the energy available in the wind. However, the actual mechanism of dynamic soaring was not clearly disclosed until Klemperer (*14*) published his paper. Reduced to its simplest form, dynamic soaring is merely correcting for the turbulence in the air mass in such a way that potential energy is gained. Klemperer's contribution points a clear path toward the duplication of this process by man. So far, only certain birds are known to utilize dynamic soaring—in particular, the albatross.

The strict condition to be fulfilled, as Klemperer points out, is that the sailplane or bird must be immobile against pitching under the influence of gusts. Under this condition, an upwardly direct gust results in increasing the angle of attack, thereby lifting the bird or sailplane. A gust having a horizontal component of velocity will result in an increase in effective air speed, thereby increasing the lift. In practice, this process might be accomplished on a sailplane by using modern gyroscopes and servo controls.

A simple model of an analogy for dynamic soaring is shown in Fig. 13. By oscillating the model along its axis with a higher acceleration in the forward direction than in the reverse, the marble is made to climb to the last stage of the model. Interestingly, Bazin (*15*) and Lanchester (*16*) invented this analogy independently.

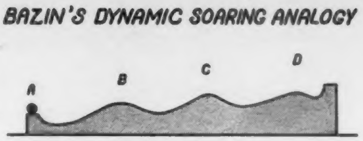


Fig. 13. Bazin's dynamic soaring analogy.

Idrac (*17*) in his carefully documented study of the soaring flight of birds, described a second type of dynamic soaring practiced by the albatross. This bird flies an elliptic path, one vortex of which is in an area of high-velocity flow and the other near the water's surface, in wind of relatively low velocity. In other words, this bird utilizes the energy in the boundary layer of the earth.

The last phase of soaring has yet to be accomplished by man, although many have tried it. The Russians have recently (1956) flown a sailplane with elastically supported flapping wings capable of being "tuned" to the turbulence. No significant gains were reported, nor was any demonstration made to indicate such gains. Perhaps we need to study the dynamic soaring of birds in more detail before we can hope to succeed.

The last and least understood phase of bird flight is that of flapping. Aerodynamic theories for unsteady lifting of wings have been developed, but still there is much to be learned from the complex flapping motion of flexible wings, having slots which can open or close in various phases of the flapping motion.

In so far as the actual motions of flapping flight are concerned, by far the best description is contained in the documentary work of Marey (*18*), who used a time-lapse photographic technique to define the flapping motion of the wings of birds. His three-dimensional models showing the flapping sequence are works of art. However, his studies, while of historic interest, contribute little to an exact understanding of the physical mechanism of bird propulsion by flapping.

Of the more recent works in the field of flapping flight, there is the work of Küchemann and Weber (*19*). In a chapter of their book entitled "Aerodynamic propulsion in nature," the authors make a clear comparison of the oscillating wing and the propeller.

At the very low speeds of landing and take-off of birds, the propulsive efficiency of a propeller would be rather low. However, if the entire wing span is used to accelerate a large mass of air above it, thereby achieving a change in momentum with a relatively small velocity increment applied to the large mass, the efficiency remains quite high. In fact, if the flapping wing as a propulsor could be designed for airplanes which are to take off and land in short distances, it would provide a very important contribution in its high propulsive efficiency at low speeds.

The actual power required for flapping flight and the propulsive efficiency of the bird have not yet been measured. This is a challenging problem, but one fraught with experimental difficulties. However, with modern miniaturized instruments and telemetering, it should be possible to gain some insight into this problem.

From the zoological side, there has been a very thorough study made of the musculature of buzzards by Fisher (*20*). However, the question of determining which muscle plays a part in delivering power to the wing has not been satisfactorily answered. If it were, we would be able to determine the power output which these muscles can provide for flapping flight.

From the standpoint of the biophysics of bird flight, we probably can sum up the state of our present knowledge by saying that we know very little. A few measurements have been made which were quite revealing when the bird was compared to man's creation, the airplane. However, there are still many facets which challenge both the experimentalist and the theorist in this field of natural flight. It is my hope that some of these challenges will be accepted by biologists, physicists, engineers, and mathematicians.

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How Did Life Begin?

Recent experiments suggest an integrated origin of anabolism, protein, and cell boundaries.

Sidney W. Fox

The scientific question of the mechanism of life's beginning is a more sophisticated version of the personal question, "Where did I come from?" This question, appropriately phrased, is one which man generally has long asked himself and which man individually asks from his early childhood. If we accept the proposition that the impetus of the scientist is truly curiosity, virtually all thinking men are to a point scientists because of their special curiosity about this problem.

One consequence of such widespread concern is the large amount of writing on the origin of life. The total number who have done little or no experimentation but have conjectured in print about this problem is remarkably large. The number who are currently active in putting ideas to experimental test is, however, remarkably small. Despite this emphasis, there are many whose thoughtful analyses should be credited with providing stimulating ideas and an increasingly favorable intellectual climate. Especially pertinent are printed speculations of Oparin (*1*), Bernal (*2*), Urey (*3*), Rubey (*4*), and Wald (*5*). Inasmuch as the experiments in our laboratory are treated here in some detail, I am pleased to acknowledge also careful and devoted collaboration, especially that of Kaoru Harada.

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The first international symposium on the origin of life was held in Moscow in 1957 under the auspices of the International Union of Biochemistry (*6*). The subject matter was at that time divided into five consecutive stages. A similar division involves (i) synthesis of organic compounds and (ii) synthesis of simple biochemical substances. The majority of the experiments which have been performed fall into these first two stages, which at times are telescoped into one stage. These experiments report production of, principally, amino acids under presumed prebiological conditions. The fact that the production of these biochemically significant organic compounds falls into one or both of the first two stages underlines the outlook that amino acids are rather far from being synonymous with life, a relationship which has not always been recognized.

Stage (iii), having to do with production of large molecules, such as proteins, has received experimental attention for almost as long as have the amino acids, with far fewer results.

It is to be expected that life will ultimately be found to have arisen in stage (iv), which has to do with organized cellular structure, or in stage (v), which concerns evolution of macromolecules and metabolism, or during both. There are in fact reasons to believe that, although it is analytically useful to think of these stages one at a time, the first life involved a simultaneous orchestration of all five.

Production of Amino Acids

Insofar as I am aware, the first bold experiments expressly constructed to provide information on stage (i) in prebiological chemistry were those of Calvin and his associates (*7*). Treatment of carbon dioxide and water in a cyclotron gave significant yields of formaldehyde and formic acid. The production of formaldehyde permitted visualization of the formation of carbon-carbon bonds and, therefrom, of a sufficient variety of organic compounds. Calvin's experiments have been criticized on the basis that the prebiological atmosphere contained only a small proportion of carbon dioxide. One answer to this objection is that no more than a small proportion of any material was needed for the germ of life. I see no adequate basis for assuming, as has often been done, that the origin of life is necessarily a general geochemical problem.

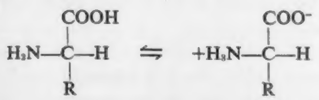
An experimental demonstration that especially focused attention upon this field of inquiry was the production of amino acids by electrical discharge in a mixture of methane, hydrogen, ammonia, and water, as reported more than six years ago (*8*). Miller obtained a few natural amino acids, some that are not found or are very rarely found in proteins, many ninhydrin spots not so far reported as identified, and other acids (*9*). Amino acids are of course more significant in our context than are formaldehyde and formic acid, and the experiments leading to production of those organic compounds are especially well known, undoubtedly for this reason.

Looking backward from 1960 we can see that, in fact, a majority of published experiments in this field have dealt with production of amino acids. These results are comprised in more than ten papers describing scores of experimental modes for production of amino acids under conditions that can be designated prebiological (*10*). One of the discernible reasons for the emphasis on amino acids is the fact that these substances are the components of pro-

Table 1. Examples of effects of thermal polymerization of amino acids.

Leucine ⟶	diketopiperazine, tar
Phenylalanine ⟶	diketopiperazine, tar
Tryptophan ⟶	tar
Aspartic acid + leucine ⟶	linear peptides
Glutamic acid + phenylalanine ⟶	linear peptides
Lysine + alanine ⟶	linear peptides
Excess aspartic acid + excess glutamic acid + 16 common amino acids ⟶	linear peptides containing all 18 amino acids

tein. It is difficult to visualize a primeval form of life which was not protein-centered in the same way that all current terrestrial life is. Another reason is the fact that amino acids, thanks to paper chromatography and ninhydrin, are easily identified. Another fundamental reason is that amino acids are relatively stable organic compounds. This stability inheres in the fact that they are organic salts. The equilibrium between

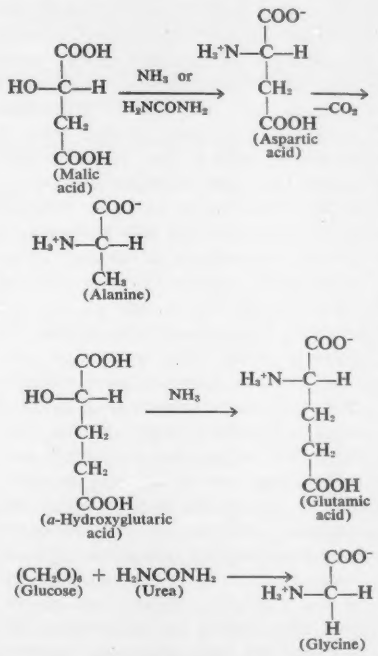


the charged and uncharged forms, has been shown to be predominantly on the side of the charged form (*11*). The salt-like structure imparts a degree of thermodynamic stability. If one provides a mixture of simple inorganic compounds of carbon, hydrogen, oxygen, and nitrogen with enough of any kind of energy to produce any organic compounds, production of some amino acids should not be unexpected, for this reason.

One of the many other modes of production of amino acids, by way of example, is that of Bahadur (*12*). Under the action of sunlight he obtained from formaldehyde and nitrate many amino acids identified by paper chromatography and three which were more fully characterized. Oro' and his co-workers have recently also used formaldehyde, with hydroxylamine, in thermal synthesis of amino acids (*13*).

Inasmuch as amino acids can be produced in so many presumably prebiological ways (see also *14*), one is unable to narrow the range of speculation about the nature of the geochemical matrix to any truly helpful degree.

Our own laboratory method of producing amino acids has been thermal (*15*). These acids arose in experiments aimed at producing protein in a prebiological context. Many other unexpected compounds were formed. With support from the literature, the results can be related in one continuum of physical conditions to all of the five stages mentioned earlier. Some of the ways in which four amino acids have been produced thermally from intermediates used also by organisms are as follows:



No special argument is offered for the thermal mode of generation of amino acids in contrast to the many other mechanisms, except for the fact that with the former method amino acids can be produced under the same physical conditions that cause their polymerization. In recovering amino acids from the reaction of ammonia or urea on a hydroxyacid, it is in fact frequently necessary to hydrolyze the polymer formed in the same treatment.

Production of Proteinoids

In view of the premise that early organisms were protein-centered, the terrestrial origin of protein is a more penetrating question than the origin of amino acids. A plausible answer to the question of the origin of protein (*16*), based on experiment, has begun to take definite shape recently. At the outset, the initial experiments unexpectedly yielded results which offered clues suggesting the comprehensive origin of biochemical systems, and more recently of organized or cellular systems.

The study leading to the syntheses of polymers with many properties of proteins was one of molecular evolution (*17*). The related interpretations included a Darwinian explanation of the known and then perplexing heterogeneity of protein molecules (*18*) and the provocative realization that the two acidic amino acids, aspartic acid and glutamic acid, are relatively dominant throughout the proteins and many internal fluids of plants and animals. The added inference that evolution of protein molecules, especially of homologous types, has been unexpectedly slow led to the carrying out of experiments to produce a presumably primordial protein. There were a number of reasons for selecting thermal energy to test polymerization of amino acids despite the fact that carbonaceous destruction of these substances is well known to be a dominant result of heating (*19*). The critical conditions that made an almost white polymer of 18 amino acids obtainable were found to be dry heat in the presence of excess dicarboxylic amino acids, aspartic acid, and glutamic acid. The temperatures used (150° to 200°C) are consistent with assumptions about the thermal history of the earth beneath or at the surface, whether one subscribes to the theory of a "hot" origin or of a "cold" origin of this globe (*20*).

The term *proteinoid* is employed to indicate a polymeric preparation containing, in peptide linkage, all or most of the amino acids common to protein.

Before we examine some of the properties of the proteinoids, mention should be made of other attempts to attain a similar objective. The most progress may seem to have been reported in experiments concerned with the action of ultraviolet light on aqueous solutions of amino acids (*21*). The simple peptides, glycylglycine and glycylalanine, were reported as products, but in trace amounts which were identified only by qualitative paper chromatography. Low conversions of amino acids to peptides are to be expected anyhow from considerations of equilibria (*22*), whereas understanding the evolution of bioenergetics requires conversions much higher than the few percent allowed by thermodynamics. Attempts by Miller to find biuret-positive material in his electrically produced products have been reported as unsuccessful (*9*). Akabori and his colleagues have ex-

perimental evidence for the direct substitution of the simple polymer polyglycine by serine and threonine residues to yield a somewhat variegated peptide (*23*).

Our earlier experiments began with the premise that prebiological chemistry is reflected in biological chemistry. Since organisms synthesize their protein from preformed amino acids, it was deemed most probable that prebiological protein was also generated from preformed amino acids. This recapitulationist outlook (*17*) is consistent with that of others, notably Brachet (*24*). This constitutes also a reason for preferring to experiment first with condensation of amino acids rather than to alter preformed peptide chains which lack highly variegated side chains, such as polyglycine. The same reasoning was also responsible for selecting amino acids as reactants instead of the easily polymerizable N-carboxy amino acid anhydrides (*25*), which do not to our knowledge have a close counterpart in nature. The involvement of phosphoric acid would, however, accord well with the findings of comparative biochemistry. A listing of examples of homopolymerization, copolymerization of pairs of amino acids, and multiple polymerization of 18 amino acids is found in Table 1. Most amino acids, when heated individually, yield tars and other unwanted products such as diketopiperazines. When two or more amino acids, one being aspartic acid, glutamic acid, or lysine, are heated together, mixtures of genuine peptides result, as well as some diketopiperazine. Since a large proportion of acidic amino acid effects reaction of neutral amino acid, excess acidic amino acid was utilized simultaneously with all of the neutral and basic amino acids common to proteins to give, in yields of 15 percent or more (some yields are much higher), polymers containing all of the reacted amino acids.

When the thermal polymers containing the 18 amino acids common to all organisms were first obtained, it was immediately apparent that such polymers resembled proteins in some respects. An exact appraisal of such resemblance requires extended scrutiny, and many special details of the structure of natural proteins are yet to be evaluated (*11*). It has, however, been possible to compare more than ten properties of natural protein and the synthetic polymers. In making these comparisons we are indebted to many chemists who volunteered aid (*26*).

Points of Comparison

Let us review briefly the principal points of comparison. Natural proteins of low molecular weight and the synthetic proteinoids have, in addition to the primary attribute of containing the same amino acids, other identical or overlapping properties as follows: elemental analysis, positive standard color reactions such as biuret, xanthoproteic, and Hopkins-Cole; similar infrared absorption spectra, range of molecular weights, solubility properties (including a tendency to be salted in and salted out), and electrophoretic mobility. In addition, they function as proteolytic substrates, they have nutritive value in replacing peptone for bacteria, their amino acid units show some degree of order which is the same in repeated polymerizations, and they possess morphogenicity—that is, a tendency to assume definite shapes. From the polymer are recovered D- as well as L-amino acids on hydrolysis. In this respect the polymer differs from mammalian protein. There is, however, some evidence of considerable proportions of D-amino acids in proteins of many bacteria (*26*). Tests for antigenicity in rabbits and guinea pigs have so far been negative. This is a principal way in which the synthetic polymer is distinguishable from most proteins. Among the explanations advanced for the non-antigenicity of the synthetic polymer, one of the most likely seems to follow from the fact that the mean molecular weights of the synthetic materials overlap only the lower end of the range of molecular weights of natural proteins as often defined. Antigenicity is found usually in proteins of molecular weight greater than 15,000. Ways of increasing molecular weight are being investigated, and additional tests for antigenicity are planned. Pirie and others have suggested that the proteins of highest molecular weight developed only after the first organism evolved (*27*). Similarly, since antigenicity is more characteristic of native than of denatured proteins, antigenicity might have developed only after organisms had evolved very subtly structured proteins.

Figure 1 is a chromatogram of a hydrolyzate of the synthetic polymer. The qualitative pattern for casein or any other protein is essentially the same. The synthetic polymer was prepared by heating at 170°C for 6 hours one part each of aspartic acid, glutamic acid, and an equimolar mixture of the 16 other amino acids. The product was aseptically dialyzed to free it of smaller molecules, and was dried and hydrolyzed (*28*). All the amino acids are present in considerable proportions, except for serine and threonine, of which there are only traces. These results were confirmed by microbial assay and column assay in two other laboratories.

The mean molecular weight increases from 3600 in a proteinoid made at 160°C to 8600 in one made at 190°C. These values were determined by end-group assay and may be compared with a value of 6000 for insulin, whereas the mean molecular weight of peptide per assayable end group of insulin is approximately 6000/2 (or 3000). Mean molecular weights of other thermal polymers containing all of the amino acids have been determined by the Archibald technique in the ultracentrifuge in John Edsall's laboratory, and

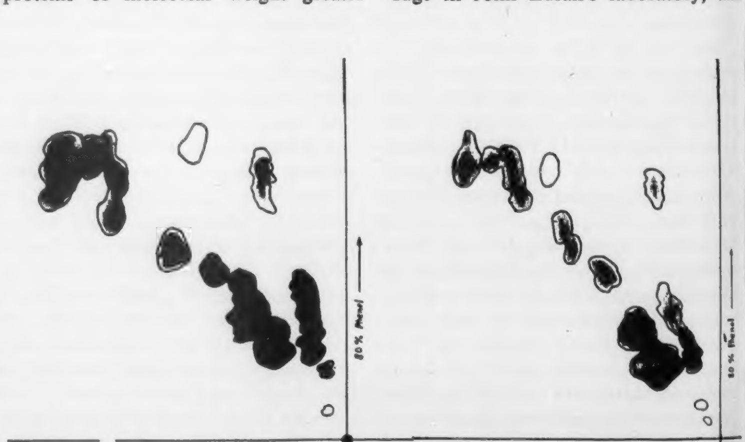


Fig. 1. Two-dimensional chromatogram of hydrolyzate of casein and of a proteinoid.

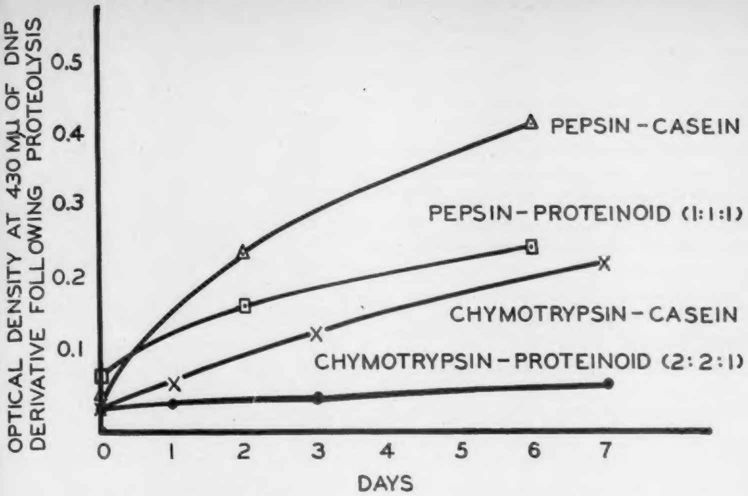


Fig. 2. Proteolysis of proteinoid by pepsin and chymotrypsin.

by the Craig dialytic method. Mean molecular weights for all these polymers fall in the range of many thousands.

The susceptibility to proteolysis of the thermal polymer is shown in Fig. 2. It is evident that proteolytic enzymes such as chymotrypsin and especially pepsin can act upon this material as upon the substrate to which they have been adapted in evolution. Essentially no splitting is observed in controls without enzyme. G. Krampitz has recently reported that thermal polymers of amino acids are also split by trypsin and papain (*29*). One can infer that the thermal treatment yields peptide bonds which behave normally in this respect and that the elevated temperature employed in synthesis does not produce secondary structures which mask all such bonds. The additional fact that bacteria can use these materials for protein nutrition is presumably a manifestation of the action of bacterial proteases.

Somewhere in the transition from the inanimate to the animate world, order such as is often ascribed to units in natural protein should have arisen. Table 2 presents data bearing on this point. Briefly, in each case, the proportions of aspartic acid, glutamic acid, and (collectively) the 16 other amino acids in the product differ markedly from those proportions in the reaction mixture. Also, the proportions in one position in the peptides, the N-terminal, differ markedly from those in the total composition. This result is typical of many which show the same kind of trend (*26*). The evidence thus indicates that the thermally reacting amino acids influence their own order. These results, in turn, suggest that nonrandom arrangements could have arisen in the first protein molecules before presumed templet or other mechanisms were sufficiently developed to govern, or perhaps largely to fix, the order of residues.

One can find individual proteins which have all of the properties possessed by the proteinoids except possibly the nonantigenicity, a point which requires qualification. Due to the variation in proteins, exact comparison presents some difficulties, but in essence these criteria do not permit distinguishing proteinoid from natural protein, or polypeptide, of molecular weight approximately 10,000.

Temperatures

The research to this point was based on our unwillingness to accept several commonly held assumptions, the most notable of which is the expectation that organic compounds are not sufficiently stable at the temperatures first employed for polymerization. This antithermal philosophy still persists (*30*), but the beneficial effect of starting with dry or, at the most, moist reactants in order to obtain the results reported here cannot be overemphasized (*31*). The conceptual difficulties for high temperature are aggravated by the unwarranted assumption that there were long geological periods in which unrenewed compounds were heated. A different assumption is the dynamic and continual generation of prebiological compounds, a picture consistent with the continual generation of compounds in organisms. It is of added interest that thermophilic organisms have been proposed as the most ancestral (*32*). It is also worthy of note that many of the organic compounds in nature, especially the polymeric proteins, polysaccharides, and nucleic acids, are schematically dehydration products (*33*). Although their results were not interpreted in the context of origins, Mora and Wood have recently shown that polyglucoses may be made from the monomeric glucose at temperatures of 140° to 170°C (*34*).

Despite the fact that temperatures above 150°C cannot be ruled out as one of the primordial conditions, it has been possible to lower substantially the necessary temperatures for polymerization in the laboratory. Yields have been enhanced by the addition of phosphoric acid, polyphosphoric acid, and various phosphates including adenosine triphosphate (*35*). One of the most active forms is a polyphosphoric acid which yields at temperatures as low as 70° significant amounts of polymer from 15 amino acids (*36*). This finding is of particular interest when it is compared with the known activating effect of phosphate in protein biosynthesis (*37*). The suggestion that there is a correlation is enhanced by the fact that experiments in which the phosphoric acid is replaced by sulfuric acid show that the latter fails to produce any polymer; sulfate is likewise not implicated in biosynthesis.

The finding that amino acids can be polymerized at a temperature well below 100°C underlines the futility of extended debate about experiments be-

Table 2. Distribution of amino acids.

Proportions in reaction mixture			Proportions in product			Proportions in N-terminus in product		
Aspartic acid	Glutamic acid	ΣBN*	Aspartic acid	Glutamic acid	ΣBN*	Aspartic acid	Glutamic acid	ΣBN*
33	33	33	55	13	32	7	30	63

* ΣBN, 16 basic and neutral amino acids determined collectively.

Table 3. Variation in spherules with variation in constitution of the polymer.

Polymer	Nature of unit
Proteinoid	Spherule
Aspartic acid-glutamic acid	Spherule
Aspartic acid-lysine	Spherule
Aspartic acid-leucine	Spherule
Aspartic acid-methionine	Spherule
Aspartic acid-glutamic acid-leucine	Spherule
Glutamic acid-glycine	Oblate spherule
Alanine-aspartic acid-glutamic acid-glycine-diaminopimelic acid-glucosamine	Nonuniform spherule
Polyglycine	No spherule
Polyaspartic acid	No spherule

fore there has been time to conduct and report them (*30*, *31*). The results de-emphasize the alleged difficulties arising from laboratory temperatures of 150°C and emphasize instead the intellectual difficulties created by negative assumptions which, if viewed seriously, can paralyze experimentation.

The fact that it is possible to effect the polymerizations at an appreciable rate at temperatures below 100°C permits renewed investigation of experimental studies involving origin and retention of optical activity. It has, however, been evident for some time that several potential explanations, biological and chemical, exist for the origin of optical activity (*5*, *38*). The question is, rather, which mechanism or mechanisms were actually involved. The concept of spontaneous resolution in this context has gained some renewed favor with the demonstration that DL-glutamic acid can be resolved simply by seeding with one enantiomorph (*39*).

It is now clear that it is possible to produce by thermal polymerization many peptides which vary in molecular size, in composition, and in other physical properties. In addition, when compounds other than amino acids, of the nature of so-called prosthetic groups, are included in the reaction mixture, the characteristics of the products are altered. Polymers of each kind are being systematically surveyed for enzyme-like activity. Aside from conclusive demonstrations of catalytic activity, answers to related questions of interest are being sought: How many kinds and how much enzymic activity of each kind are present? Will the results suggest that much of the enzymic power of current organisms is itself the result of Darwinian evolution, a possibility that has been proposed by several workers, or was the most primitive organism highly self-sufficient in this respect?

The basic question of whether proteinoids have catalytic activity may be viewed against the known fact that peptides, such as polyhistidines, otherwise prepared, are hydrolytic catalysts (*40*), the known thermal stability of yeast invertase and other enzymes in the dry state (*41*), and the widely held notion that much evolution of enzymes occurred during the era of the beginning of life (*42*). When the questions about catalytic activity in proteinoids are answered, it may be apparent that the more basic question was that of the origin of large molecules combining a variety of amino acids through the peptide bond.

Morphogenicity

One of the properties of the synthetic material is its morphogenicity. A tendency to yield microspheres having diameters in a bacterial range is illustrated in Fig. 3. Typically, 1 billion of these units result from treating 15 milligrams of the proteinoid with 2.5 milliliters of hot water and allowing the clear solution to cool for a few minutes. The units shown are approximately 2 microns in diameter. These were formed in sea water and centrifuged; after centrifugation they were found to have retained their integrity (*43*).

Another property of the microspheres is the tendency to shrink in sodium chloride solution hypertonic to that in which they are produced. In such cases the spherules assume a volume much less than that of the original. Such experiments are carried out in solutions previously saturated with the thermal polymer, so that changes in size cannot be ascribed to solution. Accordingly, the behavior of the spherules suggests that they are osmotic. Of course, additional experiments must be performed to evaluate this.

The fusibility of the spherules prepared in the presence of certain substances, such as some lipids, suggests that useful biochemical abilities might have been combined in a similar fashion. This picture perhaps provides a mechanism for the lengthening of biosynthetic sequences envisioned in the Horowitz hypothesis (*44*), by the packaging of various groups of biochemical abilities in discrete units. Individual units which contained some synthetic capacities might then have combined with other cells which had other synthetic abilities to provide new cells with selective advantage. Other possibilities, however, such as an original autotroph, cannot yet be rigorously excluded from the larger conceptual framework.

The units described differ in many ways from most previous cell models, especially in being composed of polypeptide material. Oparin's coacervates, however, are made from gelatin and other materials (*1*). Here the properties are somewhat different. One salient difference is the fact that these spherules are the product of a continuum of phenomena suggesting successive biochemical and physiological origins. Secondly, inasmuch as our material is synthetic it is possible to vary its constitution over a wide range and thus to explore the variation of properties of spherules with that of the constitution of the polymer. Many variations have been examined; the property is evidently associated with many thermal copolymers of amino acids. We are thus not restricted to material of recent evolutionary origin, such as gelatin. It is, of course, of more interest to compare the thermal cell models with natural cells than with coacervates and to define, and experiment with, these differences.

Some of the variation is presented in Table 3. One salient feature is that polymers prepared with the inclusion of such special amino acids as diaminopimelic acid, found almost only in blue-green algae and some bacteria, yield also a sphere-forming polymer, but the units obtained are larger on the average, and not so uniform in size. A glutamic acid-glycine polymer gives units resembling erythrocytes in shape. Proteinoid synthesized in the presence of starch yields sickle-shaped units. Inclusion of ribonucleic acid or deoxyribonucleic acid in the hot water from which the spherules are made provides also some structural effects.

The tendency of varied polymers to form varied structures morphologically indicates that, despite the seemingly brutal thermal origin, fine differences in supramolecular and molecular structure are obtained (*45*).

Prebiological Origins

As stated, it becomes possible to visualize, on the basis of such experiments, physiological as well as biochemical origins. Probably prebiological evolution was gradual, as has been asserted by others, but events punctuating the organization of prebiological activities must have had a signal character. The first sudden production of osmotic boundaries in the primitive, presumably warm sea or in a perivolcanic spring must have been a momentous event for subsequent life. At this significant instant there appeared not only the form of the most luxuriant unit of life that we know but the first environment. Some of these first units could do prebiochemical business, and subsequently biochemical business, with that environment. The universal necessity for nutrition of all cells has been with us ever since (and I use "us" in the basic Darwinian sense of kinship with all living things). Also with us has been the eternal problem of understanding the relationship of the individual to his environment, a problem which has grown much more complex and vexing than it could have been at the moment of its remote evolutionary origin.

Another aspect of interest for future study is the relationship to optical activity. The finding that spherules can form from polymers composed of both D- and L-amino acid units was somewhat surprising. The conversion of polymers to spherules is typically one-third by weight. The possibility of optical enrichment in or by the spherules has not yet been investigated.

Another feature of such processes as the polymerization and spherule production in a continuum is their stark simplicity. These are processes which could have occurred on the primitive earth, before the establishment of scientific apparatus supply firms; only the natural geological crucible would have been required.

These considerations underline also another inferred feature in these processes—a repeatedly observed tendency toward self-organization (*46*).

The first experiment on thermal copolymerization of amino acids gave unexpected products and led to research which for 3 years also essentially organized itself. A principal part of the results is shown in Fig. 4. These are thermal pathways indicating the production of amino acids from Krebs-cycle acids (malic acid or fumaric acid), of one amino acid from another, and of the vitamin intermediate β-alanine from aspartic acid; the polymerization of amino acids; and the production of a nucleic acid biointermediate, ureidosuccinic acid (*38*). These compounds are all true biochemical substances except for some of the macromolecules and some DL forms that take the place of the natural L types. Most striking is the fact that the sequences of reactions are like those of a generalized biosynthesis. It was in fact possible to suggest in 1955 (*17*) a confluence of major biochemical cycles; in part this was also proposed in 1956, by Reichard and Hanshoff, on the basis of conventional biochemical investigation (*47*).

The finding of ureidosuccinic acid is essentially the only experimental demonstration yet published dealing with the prebiological origin of nucleic acid. Many thermal experiments are thus suggested, and these are being pursued. The results with proteinoid, of course, suggest experiments on a similar thermal route to nucleic acid-like materials. So far it appears more certain that polyribose has been produced than that polyribonucleotides have been (*48*). This goal is of interest because the gene, and therefore in some way nucleic acid, is believed to represent the apex of biochemical organization (*49*). Prebiochemical organization, however, probably proceeded from simplicity to complexity rather than the reverse, and the gene is molecularly most complex.

The notion that amino acids contributed to their own order in polymers before life began is not incompatible with the belief that nucleic acids govern this order in living cells. It may also now be possible to experiment with the

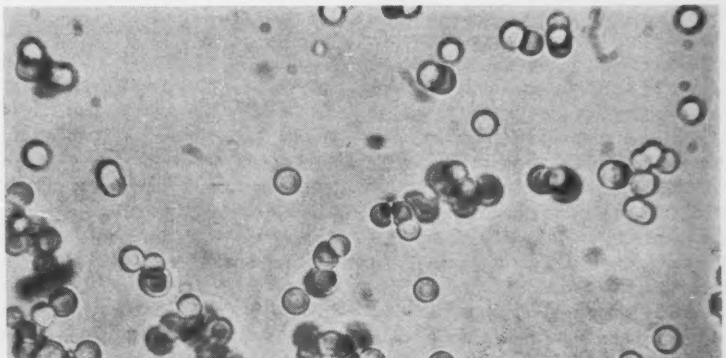


Fig. 3. Individual and aggregated microspheres from hot 0.1N potassium thiocyanate solution and 2:2:1 proteinoid (*43*) ($\times$ 1550).

effect of nucleic acids on ordering in thermal polymerization and to draw some inferences regarding the most likely stage at which nucleic acids may have entered the prebiological or biological picture in this function. A related point is that nucleic acid components arise biosynthetically through amino acids (*38*).

Summary of Research

In attempting to summarize research on how life began, we can see that for the first time, in the decade drawing to a close, a number of laboratories have supplied experimental demonstrations of the way in which isolated chemical aspects of life might have arisen spontaneously. This kind of research has gained much respectability which it formerly did not possess. The various contributions have involved one or two of the five stages of prelife. One experimental program and theory, that which is predominantly thermal, has connected parts of each of the five stages in a continuum which proposes many living phenomena as inexorable consequences of preceding phenomena. The fact that this mode is thermal primarily reflects the circumstance that thermal experiments continue to beget thermal experiments. It does not signify that other modes of energy were not involved in the emergence of life, particularly in the first stages in which the simplest organic compounds arose.

An integrated outline conceptualization of the way in which life might have begun in an orderly sequence of events, drawn largely from the thermal experiments, is presented in Fig. 5. The chemical reactions through the micromolecules might occur in any of many ways which have been demonstrated in many laboratories. The polymerization of amino acids on one hand or of pyrimidines, purines, and ribose on the other would occur in a hypohydrous—that is, a dry or at most moist—reaction mixture at moderately elevated temperature. The hypohydrous, dry, or phosphoric state would characterize steps *A*, *B*, and *C*. According to this concept, concentration of compounds in an oceanic soup would be unnecessary because the reactions occur with little water from the outset. The resultant mixtures of polymers and numerous reactants in a state of linked and continuous generation would, when subsequently discharged into a primitive aqueous pre-environment (step *D*), yield osmotic boundaries, with enzyme material and preanabolites in an intimate relationship. Prebiotic selection of proteins with catalytic activity would begin at step *C*. A first cell division would occur at step *E*, and dissociation of nucleoprotein, at step *F* to release or generate selected enzymes to catalyze the chemical steps which would constitute a repetition of the first cycle. The minimal cycle needed for repetition of itself would then be subject to deviations some of which would have selective advantage. Molecular evolution would proceed through step *G* (*17*).

This postulated cycle recognizes the interplay of experiment and theory not only for biochemistry as defined by substances but also for linked, continual, and dynamically related reactions, for the generation of protein to provide varied enzymes to catalyze the reactions, and for the development of a physiological organization to contain and repeat those processes. The last-mentioned phenomenon of replication is one that stands out among those phenomena for which no experimental model is at hand. An adequate cellular biosynthesis is another missing piece in the puzzle, and there can of course be others. The inferences arising most closely from the experimental model are (i) spontaneous generation of biochemical pathways, including production of amino acids and nucleic acid intermediates, (ii) origin of protein in intimate relationship in the same reaction mixtures, and (iii) spontaneous separation into preliving units and environment when the system became aqueous, all of these steps occurring in an evolutionary and physical continuum. Incidentally, we are justified in thinking of Darwinian selection of molecules in prelife if these molecules persist into, and confer advantage on, the first organism (see *50*).

Position of Viruses

Among the controversies which lace our subject matter are those that concern the definition of life and the position of viruses. Recently Pigman has discussed in a book review the postulate that viruses are a bridge between molecules and cells, and has referred to "the great difficulty that known viruses seem to be parasitic degenerate forms of cells incapable of surviving under the probable cultural conditions of the pre-life era, even if the seas were filled with synthetic amino acids and peptides."

Until someone succeeds in cultivating a virus in the absence of cells, many viewers of the scene will be unable to regard a virus as an evolutionary bridge between molecules and life, although virus molecules bridge the

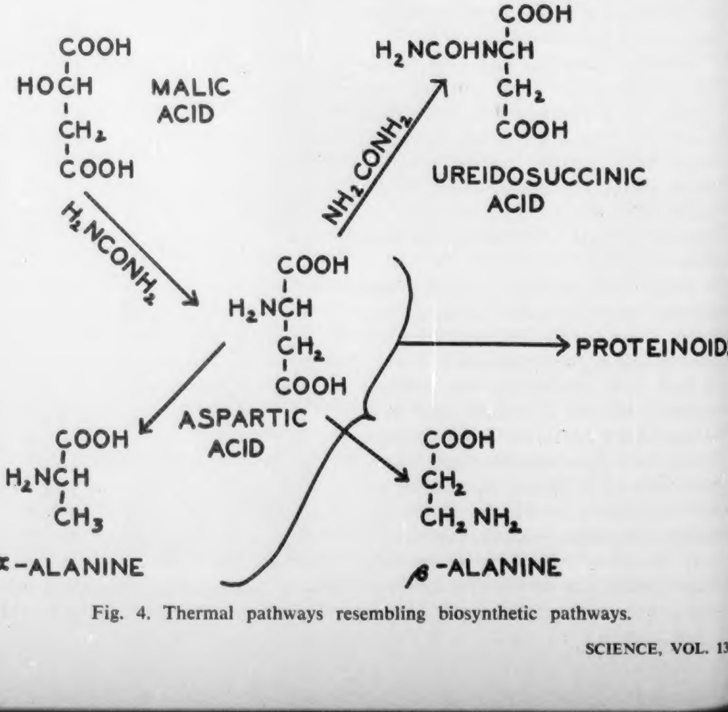


Fig. 4. Thermal pathways resembling biosynthetic pathways.

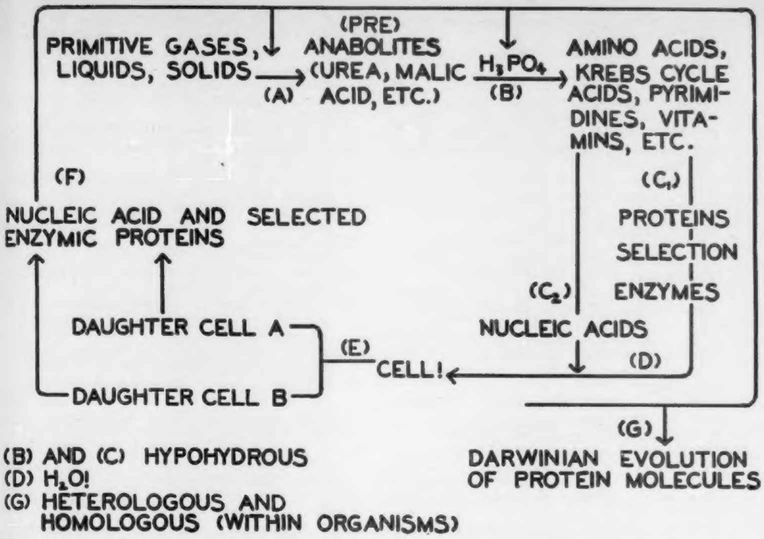


Fig. 5. Postulated first cycle leading to life, its reproduction, and mutation.

two realms from the standpoint of size (*51*). The controversy may actually disappear when considered in the rigorous context of life's beginning, by perception of the fact that a virus is not alive simply because it cannot be replicated in the absence of cells, and that cells would thus have had to appear first. One cannot, however, rule out the possibility that primitive viruses had more competence than their current lineal descendants, which may be more recently adapted to cells.

In the same general context, an enzymically synthesized, biologically active polynucleotide cannot be considered to be synthetic life until the enzyme is totally synthesized first, if it may be considered to be so even then.

Unified Outline Theories

At the present moment there is new reason to entertain seriously the germ theory of the origin of life. Kluyver and Van Niel, who did so much to help establish the concept of the "unity of biochemistry," developed one evolutionary picture of bacteria which began with the cocci (*52*). It is the cocci that the thermally produced spherules particularly resemble in range of diameter. Size and shape taken together are, of course, fundamental to taxonomic evaluations in the bacteria.

The significance in 1960 of a continuum embracing both molecular and cellular phenomena can be stated by a quotation from Michael Tswett, who said in 1908 (*53*): "It is too often forgotten, especially on the chemical side, that living tissues are not mere mixtures of compounds remaining in chemical equilibrium, but are organized structures, where, as a result indeed of osmotic boundries, the most varied reactive bodies stand next to each other. . . ."

The question "How did life begin?" focuses attention upon subtle but important differences between the verb *begin*, used intransitively, and the verb *start*, used transitively. We assume that someone some day will succeed in producing a cell which metabolizes and reproduces itself and its metabolic pattern in such a manner that no experts will disagree with the conclusion that the unit is alive. When that occurs, a chemical evolutionist will have *started* life, whereas that from which we are descended *began*. Will we be able, then, to say that the experimental demonstration reveals how life began? At first glance the answer seems to be negative. It should be possible, however, when life has been synthesized, to determine the latitude of each of the conditions required for synthetic life, and perhaps the latitude of some of them before life is started. As a hypothetical example, we now know that some synthetic polymers will not yield spherules, as reported in Table 3. When the full scope of conditions necessary for the synthesis of life is determined, it should be possible to judge whether these are conditions associated with the current earth, with what we believe to have been the prebiological earth, and with conditions prevailing on other planets.

A related thought is that life may be beginning now. Although we can with certainty say only that life arose at least once, there is increasing reason to believe that life can, or even must, arise in many places at many times. The common floral pattern of many hot springs areas and concepts of parallel evolution are consistent with this idea, and pose the possibility that we fail to recognize life beginning anew because it so resembles unevolved descendants of primitive forms already here. There is of course no assurance that life is beginning now on the earth; the point is that we have less reason to exclude this possibility than we had formerly. Perhaps we may evaluate this more precisely as we learn about the chemistry of the interior of the earth.

We must continue to entertain the possibility that one, many, or all experimental models of life's beginnings may prove to be no more than models. From the thermal model there is already a minimum gain in the discovery of methods for easily producing a variety of peptides (some of which are being studied in industry for potential utility), the discovery of convenient methods for synthesizing some amino acids, and contributions to the interesting process of microencapsulation. One of these advances was essentially an original objective in research that my co-workers and I directed. At the interpretative level, the research which has directed us has led in outline to a unified theory. This theory *at the least* indicates that a scientific answer to the question, "How did life begin?" need not be considered hopelessly incomprehensible. What can be said *at the most* is obviously subject to further experimental discipline, but experiments already performed may delineate the essential pathway of life's emergence.

However, judgments on this, or any other unified outline theory which may arise, need not wait entirely on the production of synthetic life and subsequent analyses. Darwin's theory of evolution has, for example, been judged and has proved to be intellectually useful on the basis of its consistency with much general knowledge, rather than on that of any single dramatic experiment. The same kind of evaluation is to some degree increasingly

possible with any theory of life's beginning. At the same time, we can anticipate much more rapid progress in this case from experiment than from the controlled observation employed by Darwin.

Having stirred the embers of Darwinian thinking, I should like to conclude with a popular quotation from a letter of Charles Darwin's, as recorded by Francis Darwin.

"It is often said that all the conditions for the first production of a living organism are now present, which could ever have been present. But if (and oh! what a big if!) we could conceive in some warm little pond, with all sorts of ammonia and phosphoric salts, light, heat, electricity, &c present, that a proteine compound was chemically formed ready to undergo still more complex changes. . . ."

One can again be amazed by the amount of insight expressed by Darwin, in this letter of 1871, before nucleic acid was identified, and before a simple phosphate-aided chemical route to polyamino acids ("proteine") yielding microscopic spheres could be demonstrated (*54*). In general historical perspective, we can see that, in 1960, the big *if* in Darwin's letter of 1871 is being replaced by a growing complex of more ramified *ifs*.

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Science in the News

The Democratic Convention: Kennedy's Brain Trust and His Plans for a "New" New Deal

From Los Angeles—The Democrats have held a convention and adopted a platform in which more attention has been paid to science than in any previous convention. For the first time the platform includes a plank devoted specifically to science, calling for the government to recognize its "special role in support of basic and applied research." The Republican platform is certain to echo this view. The Democratic plank is not so much a statement of policy as a reflection of the fact that the government will spend $9 billion on science and technology this year and that even heavier expenditures are inevitable, no matter who wins the election.

The more important news, though, is not in the promises in the platform nor in the routine references to the importance of science that appeared in many of the speeches. It is in the attitudes of John F. Kennedy and the people who surround him. Kennedy and his advisers, the latter including some well known figures in the academic world, are thinking very much in terms of a revolution in American life which they believe will be as important as that which followed the election of Franklin D. Roosevelt. They believe that the United States cannot compete with the Soviet Union as it is now oriented. They believe, in particular, that there must be a substantial revision in the present balance between public and private spending and that the federal government must assume a far more important role in dozens of areas, from civil rights to conservation; science and education rank high in the list of areas where they believe a very great increase in the level of federal financial support to be necessary. These things are what Kennedy was talking about in his acceptance speech when he said that America must choose between "public interest and private comfort, between national greatness and national decline."

Kennedy's Program

Kennedy's closest adviser on economic matters is J. Kenneth Galbraith of Harvard University. The policies to which Kennedy and his supporters are committed are to a large extent reflections of the position crystallized in Galbraith's book, *The Affluent Society*. Galbraith argued that as society (as individuals) has grown more and more prosperous, there has not been a satisfactory increase in spending on the things that society (as a group) must, or at least in the view of liberals, ought, to buy. Galbraith argued that there is, relatively at least, public squalor in the midst of private prosperity. Kennedy wholeheartedly accepts this view, and his policies, if he is elected, will to a large measure be aimed at correcting the imbalance.

In the field of education, for example, he is committed to a federal aid to education program of not less than $1 billion a year, covering increases in teacher salaries as well as classroom construction. He will ask for a great expansion of the student loan and federal scholarship programs-expansion aimed, presumably, at putting a college and even a postgraduate education within the reach of every qualified student. He is expected to offer programs, unspecified as yet, to relieve the financial strain on the privately endowed colleges. On scientific questions he appears committed to an atoms-for-peace program, to an expansion of international research programs along the lines of the "Health for Peace" plan, and to a very substantial increase in support for scientific research generally. He is expected to do a lot of talking about science during his campaign, emphasizing the need for scientific research to support practical programs, including disarmament. He is expected to talk about the need for increased basic research, although this is hardly the sort of thing that would make a popular campaign issue.

All of this—and it is only a small sample of what the Kennedy people have in mind—is going to cost a great deal of money. The party platform argues that the Democrats will be able to put through such big new programs without raising taxes. During the campaign Kennedy may well echo this view, arguing as the platform does that closing tax loopholes, and more important, use of the power of the federal government, in as yet unspecified ways, to assure a greater rate of growth of the economy will provide more income for everyone, including the federal government. This may be true, but such increases in federal income as may come painlessly through growth, or moderately painlessly through closing tax loopholes, are hardly likely to pay for the full cost of the new programs. The Democrats have not been talking seriously about tax cutting except as a temporary thing in the event of a recession, and Kennedy, who can be refreshingly candid as politicians go, has on several occasions conceded that tax increases may well be necessary.

In truth, Kennedy does not regard the present tax burden as too heavy by any means. He is likely to raise taxes as fast as is politically possible, for the extent to which he can carry out his program, including the scientific and educational sides of it, will be limited largely by the extent to which he can persuade the public to accept the taxes necessary to pay for it. The belief that Kennedy will be able to persuade the public to follow this road, or at least to lead the public in this direction even if it is not quite persuaded, is one of the principal things that has brought Kennedy the support of Galbraith and others who are convinced that such big and expensive new programs are urgently needed.

Wooing the Intellectuals

Kennedy has succeeded in drawing around him a still fairly small but very influential group of people from the academic world. Besides Galbraith they include historian Arthur M. Schlesinger, Jr., of Harvard University, (both Galbraith and Schlesinger were at the convention actively working for Kennedy); labor-law expert Archibald Cox, of Harvard Law School, who was in Washington helping to organize the Kennedy campaign even before the senator had

won the nomination; economists Walter W. Rostow and Max Millikin, both of M.I.T. and both specializing in the study of underdeveloped nations; Paul A. Freund and Mark deWolfe Howe, both of Harvard Law School and experts in civil rights law; and a half dozen or so others with national reputations. Kennedy has established close relations, among scientists, with Jerome B. Wiesner, of M.I.T., expert on communications engineering and disarmament, and Bruno Rossi, of M.I.T., an authority on space research, and several others.

Nearly all of these people were actively working for Adlai Stevenson in 1952 and 1956. Kennedy's success in winning them over—his ability to command the support of such people—has been useful to him in his campaign for the nomination and will continue to be useful in his campaign for the presidency. For a good many members of the academic and intellectual worlds and many influential journalists felt that Adlai Stevenson should have received the Democratic nomination, that Stevenson was elbowed aside by a "pleasant man who, without any important qualifications for the office, would very much like to be president," to use the terms in which Walter Lippmann described Roosevelt in 1932.

Role as Vote Getters

Galbraith, Schlesinger, and the rest are conscious of their usefulness to Kennedy beyond their more obvious functions as policy advisers or speech writers. They are quite willing to be used to help win Kennedy support among people who are in a position to influence the votes of other people. At least among those of them who were at the convention there seemed to be no reluctance in their support of Kennedy. They talk of Adlai Stevenson's "great heart," and they describe Hubert Humphrey, another favorite of liberal intellectuals, as "a great fighting liberal." But their support of Kennedy for the presidency seems to be wholehearted. They see in him the drive, the intellectual capacity, and above all the indefinable quality of political leadership that will get him elected and enable him, once elected, to push through the programs they believe necessary. They are conscious of the impossibility of predicting the caliber of performance of a president before he is in office, but they seem convinced that Kennedy is the best bet.

The Kennedy brain trust at this point is drawn primarily from Harvard and Massachusetts Institute of Technology, as a result of the senator's close connections with Boston and Harvard. Galbraith, for instance, has known him for years and has been a close policy adviser for 3 or 4 years. He called Kennedy the day after the senator's massive re-election victory in 1958 and formally offered to support him for the presidency. Archibald Cox had worked with Kennedy on labor legislation for several years before he offered his support in the presidential campaign. Others, working closely with Kennedy, have not been so thoroughly committed to helping him in his campaign. "We don't ask for an oath of allegiance," says a Kennedy staff man involved in gathering academic support.

The method has been for a Kennedy staffer, usually Ted Sorensen, the senator's closest policy adviser, to approach academic people to ask for advice on problems which call for their special knowledge. If the exchanges of views that result are favorable, a personal relationship tends to develop first with the staff people and eventually with Kennedy himself; still later this tends to lead to a commitment, explicit or implicit, to support the Kennedy-for-president movement. The method is not unique with Kennedy. It is a matter of importance these days for any candidate—and even more, of course, for any President—to have such a pool of expert talent available to him. The president can have it by simply asking for it. The candidate must, to a large extent, win such support, and as the roster of intellectuals for Kennedy demonstrates, he has been very successful. It is known that Senator Johnson has made similar overtures to intellectuals without much success. These men apparently simply did not feel at home with him, nor he with them. It is Kennedy's strength that once he has gotten to know a man he is likely to win that man's support for his political ambitions. This is certainly not true in all cases, but it has been true often enough so that Kennedy came to the convention with a more impressive roster of intellectuals actively working with him than any other candidate, including Stevenson.

Kennedy is not likely to win the sort of fervid commitment that Stevenson appeared to command among the intellectual community at large. But he would like to at least assuage the resentment that is now apparent among Stevenson supporters. Judging by his past performances he is quite likely to be more successful than might now appear probable. How important such support would be may seem doubtful after what happened to Stevenson in 1952 and 1956, but this past experience does not prove much, since no one knows how much worse Stevenson's defeat might have been had he not had strong support among intellectuals. Kennedy obviously believes it will be useful to have strong support among the intellectuals, and he is likely to win it.

The Kennedy Organization

Although the Kennedy organization is often described as a marvel of efficiency, some see it not so much as more efficient than its rivals but as younger, more energetic, and, above all, bigger. It is big and energetic not only only because there is money to hire a large staff. There have been many volunteer workers, mostly young lawyers and businessmen and their wives and sisters. (Kennedy was the only candidate popular enough to be able to sell rather than give away his campaign material: recordings of Frank Sinatra singing Kennedy's theme song, a quarter; a booklet on the candidate, 50 cents; Kennedy hats, $1.00.) The heart of the convention operation was "the box," a card file containing the names, preferences, and inclinations of all of the 3000-odd delegates and alternates. If the box indicated that a wavering delegate could be swayed by a talk with Schlesinger or Galbraith or James M. Burns (a biographer of Kennedy and Roosevelt), then the delegate was quite likely to hear from one of these gentlemen.

Similar attention to detail can be expected during the campaign. Members of Kennedy's staff, even before the nomination was formally his, had been looking into such things as the best ways to make use of the Democratic Advisory Committees, including the science advisory committee headed by Ernest C. Pollard, of the Yale biophysics department. The pamphlets these advisory committees have prepared have been widely circulated in the academic world, and Kennedy may well ask the committees to prepare other pamphlets on issues that develop during the campaign. The pamphlets already available—on disarmament, space, nuclear testing, and so on—will

be given even wider circulation than in the past.

All the advisory committees are made up of prominent people (the science advisory committee includes three Nobel prize-winners among its 16 members), and the managers of the operation have been delighted to find some teachers using the material in their courses.

How much influence the pamphlets will actually have on a Kennedy administration is uncertain. But it seems obvious that the academic world would have a stronger voice in a Kennedy administration than it has had under Eisenhower. The same may well be true of a Nixon administration, but this is less clear, since the recommendations of such academic committees tend to add up to a program which would require a very substantial expansion of the role of the federal government and of governmental spending. And this is a course which to some extent Nixon, and to a much larger extent the Republican party, finds unacceptable.

A report from Chicago on the Republican convention will appear here in two weeks.—H.M.

News Notes

Medicinal Chemistry Study Group

A new study section within the National Institutes of Health has been set up to evaluate research grant applications in medicinal chemistry. The NIH announcement said that creation of the Medicinal Chemistry Study Section will serve to strengthen and emphasize research grant support related to the health sciences of chemotherapy, biochemistry, enzymology, endocrinology, pharmaceutical chemistry, and pharmacology. Applications for support of medicinal chemistry research often originate in departments of chemistry, pharmaceutical chemistry, and pharmacology and are submitted by investigators who also have an interest in natural products, in the relationship of chemical structure to biological activity, or in reaction mechanisms underlying biological processes.

Chairman of the Medicinal Chemistry Study Section is Norman H. Cromwell, department of chemistry, University of Nebraska. The study section is composed of nongovernmental scientists in the fields of chemistry, pharmaceutical chemistry, and pharmacology.

Nutrition Study in Colombia

At the request of the Government of the Republic of Colombia, a team of United States nutrition experts a month ago began a survey of the nutritional status of the Colombian people, the U.S. Public Health Service recently announced. The study was arranged by the Interdepartmental Committee on Nutrition for National Defense.

Walter G. Unglaub of the Tulane University School of Medicine, New Orleans, is head of the team of clinicians, biochemists, nutritionists, dentists, food technologists, and others who, together with Colombian personnel, are examining large sections of the civilian and military population to obtain information on current nutritional conditions. The team will formulate recommendations for nutritional improvement consistent with Colombia's resources and will provide assistance in the development of standard ration requirements and in the establishment of local nutrition services.

Laboratory equipment has been shipped to Bogotá. At the conclusion of the study, the equipment will be given to the Colombian Government, under provisions of the Mutual Assistance Program, for use in operating permanent nutrition services.

The interdepartmental committee, operating administratively through the National Institute of Arthritis and Metabolic Diseases, is headed by Frank B. Berry, assistant secretary of defense, with Arnold E. Schaefer as executive director. Cooperating U.S. agencies include the International Cooperation Administration and the Departments of State; Health, Education, and Welfare; Defense; and Agriculture.

Dartmouth Plans Convocation

A public convocation on "The Great Issues of Conscience in Modern Medicine" will be held in Hanover, N.H., 8–10 September. Rene Dubos will serve as chairman of the convocation, and other participants will include Mahomedali Currim Chagla (Indian ambassador to the United States and Mexico), Aldous Huxley, Sir Charles Snow, Sir George Pickering, Warren Weaver, George Kistiakowsky, Walsh McDermott, Brock Chisholm, Ralph Gerard, Wilder Penfield, and Sandor Rado.

The convocation, which will be of interest to the layman, will consist of three panel discussions and four major addresses. Ward Darley, executive director of the Association of American Medical Colleges, will speak at the cornerstone ceremony for Dartmouth's new $3.5 million medical sciences building.

The public is cordially invited. Arrangements for lodging and meals may be made through the Convocation Office, Dartmouth Medical School, Hanover, N.H.

Science Museum Proposed

Shortly before the Congress recessed a bill to provide for the construction of a permanent museum of science and industry at the New York World's Fair in 1964 was introduced by Representative Seymour Halpern (R.-N.Y.). The bill (H.R. 12729) would authorize the federal government to erect a world center for the exhibition of scientific achievements, with the help of contributions from the state of New York, the city of New York, and private sources.

The museum would be a part of the federal government's participation in the fair, but it would remain a permanent center of international science and invention, operated by an nonprofit organization. Its collection would be modern, not historic, except insofar as historical background is essential to explain an exhibit. A chief purpose of the museum would be to make available traveling exhibits for international circulation.

A 26-member advisory panel of scientists, engineers, and museum planners and administrators would be created to assist in the design and construction of the museum.

Founders' Committe Active

Representatives of the following organizations have been active on the Founders' Committee for the museum: New York Board of Education, Business-Industry Committee of the National Science Teachers Association, American Institute of the City of New York, Engineers Joint Council, American Rocket Society, New York City Council of the National Education Association, United Engineering Center Project, National Foundation for Infantile Paralysis, New York University, City College of New York, Queens College, Brooklyn College, Hunter College, Teachers College at Columbia

University, New York City and Bronx Community Colleges, and Cooper Union.

Among individuals who have been working on the committee is George E. Probst, executive director of the Thomas Alva Edison Foundation. Albert E. Parr, senior scientist at the American Museum of Natural History, has been serving as adviser to the committee.

Translation Program

The American Institute of Biological Sciences is translating and publishing seven Russian research journals in biology. This work is supported by the National Science Foundation, which is eager that the translated material be more widely distributed to biologists throughout the world to aid research, to prevent duplication of work, to give some idea of Soviet activity in biology, and also to bring about better international understanding among scientists.

Because of the NSF support, the AIBS can offer these translations at a fraction of their publication cost, with even further price reduction to AIBS members and to academic and nonprofit libraries. The journals being translated are *Doklady—Biological Sciences Section; Doklady—Botanical Sciences Section; Doklady—Biochemistry Section; Plant Physiology; Microbiology; Soviet Soil Science*; and the *Entomological Review*.

In addition, the AIBS has instituted a separate program of translation and publication of selected Russian monographs in biology. So far six monographs have been released, and another is in preparation.

Additional information may be obtained by writing to the American Institute of Biological Sciences, 2000 P St., NW, Washington 6, D.C.

News Briefs

Phoenician colony found. The remains of an early Phoenician colony have just been found under the ruins of a monumental Roman city. The archeological discovery, at Leptis Magna on the North African coast, has been made by members of the Libyan Reconnaissance Expedition of the University of Pennsylvania Museum. Leptis Magna is about 75 miles east of Tripoli, in Libya.

Previous traces of the Punic culture at Liptis Magna were found in graves under a great Roman theater. These discoveries were made several years ago by British archeologists.

* * *

Biophysics congress. An International Congress of Biophysics will be held in Stockholm, 31 July–4 August 1961. Participants may include members of national societies of biophysics, medical physics, and related fields, and other scientists interested in pure and applied biophysics. The meeting will be divided between a series of symposia devoted to special topics in biophysics and to presentations of a number of contributed papers. Further information may be obtained from Dr. Bo Lindström at the Department of Medical Physics, Karolinska Institutet, Stockholm 60, Sweden.

* * *

Memorial Fund. An Eric Ellenbogen Memorial Fund has been created by friends of the late associate professor of biochemistry at the University of Pittsburgh. The fund will be used primarily for the education of Ellenbogen's children. Contributions should be addressed to Mrs. Maria Fuld-Conderman, 4916 Bayard Street, Pittsburgh 13, Pa.

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Physics education. Approximately 100 delegates and observers from 27 countries will take part in the first International Conference on Physics Education, which will be held at UNESCO House in Paris from 28 July through 4 August. Sanborn C. Brown of the Massachusetts Institute of Technology is chairman of the organizing committee that planned the meeting. Sessions will cover the entire range of education in physics, from secondary school through graduate study.

* * *

Weather satellite. The weather satellite Tiros I has reached the end of its operating lifetime after transmitting 22,952 film-strip frames since it was launched on 1 April. The National Aeronautics and Space Administration's 270-pound vehicle, orbiting at altitudes averaging 450 miles, has given meteorologists unprecedented opportunity to study the earth's cloud cover and relate it to our weather.

Scientists of the U.S. Weather Bureau and other cooperating meteorological groups will be analyzing Tiros data for many months to come. The data already studied have been of great significance to the field of meteorological research.

Grants, Fellowships, and Awards

Endocrinology. The University of Wisconsin Graduate School has initiated a postdoctoral training program in endocrinology. The training consists of an integrated program of laboratory research, seminars, colloquia, workshops, and teaching. Candidates for the program will be chosen on the basis of professional promise and career interest. Appointments carry a yearly stipend of $6500. Requests for applications should be directed to W. H. McShan, Birge Hall, University of Wisconsin, Madison 6.

Geography. The National Academy of Sciences–National Research Council will conduct, in 1961, its sixth Foreign Field Research Program for American geographers. The program includes all branches of geography as well as closely related fields. Applications in the fields of physical geography are specially encouraged.

The program is designed primarily for graduate students working on doctoral dissertation research, but recent recipients of the doctorate are also eligible.

Financial assistance, which varies according to the project, will provide for travel, field, and living expenses; a stipend is not usually provided. A preference will be shown for field investigations of at least six months' duration. Recipients must submit a detailed report of their field investigations. Applications for field work to be initiated before 1 April 1962 must be submitted *before 1 December 1960*. Inquiries and applications should be addressed to the Foreign Field Research Program, Division of Earth Sciences, NAS–NRC, 2101 Constitution Avenue, NW, Washington 25, D.C.

Travel. As a result of the joint efforts of the American Society of Biological Chemists and the Division of Biological Chemistry of the American Chemical Society, it is expected that substantial funds will be available from various governmental sources for support of travel of a number of qualified biochemists to the 5th International Congress of Biochemistry, to be held in Moscow, 10–16 August 1961. These funds will be available for use without restrictions as to age.

In addition, approximately $9000, raised by assessment of members of the two societies, is available for support of young American biochemists who wish to attend this congress.

Application forms are available from

the Travel Awards Committee, 5th International Congress of Biochemistry, 9650 Wisconsin Ave., Washington 4, D.C. Completed application forms must be submitted by *1 October 1960.*

Scientists in the News

Bernard Lovell, director of the Jodrell Bank Experimental Station, Jodrell Bank, England, has been honored for his services in connection with the American deep space probe, Pioneer V. On 14 July he was received by President Eisenhower at the White House, where, through the National Aeronautics and Space Administration, he was presented with a music-box model of Pioneer V. A chart showing how Lovell and his staff have tracked the satellite for 23 million miles through space was prepared by NASA for the President.

The University of Puerto Rico has announced the appointment of **John C. Bugher** as director of the Puerto Rico Nuclear Center, which is operated by the university for the U.S. Atomic Energy Commission. Bugher joins the center from the Rockefeller Foundation, where he has been serving as consultant on nuclear energy affairs. He is a former director of the AEC's Division of Biology and Medicine and at present is chairman of the commission's Advisory Committee for Biology and Medicine.

The Puerto Rico Nuclear Center was established in 1957 as part of the United States' Atoms-for-Peace program, and its work is conducted in both Spanish and English. The Center's programs, open to students from any part of the Americas, include training and related research in the application of nuclear energy in the fields of medicine, agriculture, and the biological and physical sciences.

E. L. Reynolds, research associate and head of the physical growth department at the Fels Research Institute, Antioch College, has a year's appointment as guest professor of anthropology at Hiroshima Jogakuin (Women's College), Hiroshima, Japan.

Clifton C. Doak, chairman of the biology department of the Agricultural and Mechanical College of Texas, has been appointed to head the department of biology at Trinity University, San Antonio, Tex.

Thomas N. Blumer, research scientist and professor in the department of animal industry of North Carolina State College, Raleigh, is the recipient of the 1960 Frank C. Vibrans Senior Scientist Award of the American Meat Institute Foundation. The award was established to permit a scientist, selected because of his outstanding record in research and teaching, to work during the summer months in the foundation's laboratories in Chicago.

Mac V. Edds, Jr., became chairman of the department of biology at Brown University following the retirement from that position of **J. Walter Wilson** on 30 June. Wilson will remain active as the Frank L. Day professor of biology.

S. D. S. Spragg, professor of psychology at the University of Rochester, has been appointed chairman of the university's department of psychology. He succeeds **G. Richard Wendt**, who has been chairman since 1945 and who will continue his teaching and research activities.

Gioacchino Failla, professor of radiology at Columbia University's College of Physicians and Surgeons, has retired, as professor emeritus. After spending the summer at the Marine Biological Laboratory, Failla will join the Division of Radiological Physics of Argonne National Laboratory in the capacity of senior physicist emeritus.

D. Franklin Milam, chief of the division of urology at Charleston (W. Va.) General Hospital, has been appointed associate professor of urology at West Virginia University, Morgantown.

Douglas H. K. Lee, former chief of the research program of the Army Quartermaster Corps, is now chief of the research headquarters of the Occupational Health Program of the Department of Health, Education, and Welfare, at Cincinnati, Ohio.

Geoffrey Edsall, director of the Division of Communicable Diseases at the Walter Reed Army Institute of Research, Washington, has been appointed superintendent of the Institute of Laboratories for the Commonwealth of Massachusetts and professor of applied microbiology at the Harvard School of Public Health. He succeeds **Johannes Ipsen**, who resigned on 1 July to accept the post of professor of epidemiology and medical statistics at the University of Pennsylvania School of Medicine.

The following members of the U.S. Geological Survey have received distinguished service awards, the highest honor conferred on employes of the Department of the Interior: **Charles A. Anderson, Arthur A. Baker, Robert H. Lyddan, John C. Reed, Robert L. Moravetz**, all from the D.C. area; **Robert O. Davis**, Palo Alto, Calif.; and **Eugene H. Herrick**, Rangeley, Me.

Herbert McKennis, Jr., professor of pharmacology at the Medical College of Virginia, is visiting professor at the Instituto de Fisiología in Santiago, Chile, until September. He is giving a series of lectures on special topics in chemical biology in the school of graduate studies of the medical school at the University of Chile.

Robert B. Voight, chief of the Field Division of the Bureau of the Census, Washington, D.C., became assistant to the director of the University of Michigan's Institute for Social Research on 1 July.

The U.S. Department of Agriculture has conferred Distinguished Service Awards on the following.

Henry L. Ahlgren, director, Wisconsin Extension Service.

Edward C. Crafts, assistant chief, Forest Service.

Gladys G. Gallup, director, Extension Research and Training.

Herbert L. J. Haller, assistant to the administrator, Agricultural Research Service.

Edward F. Knipling, director, Entomology Research Division.

William D. Termohlen, retired agricultural attaché to Japan.

Harry C. Trelogan, assistant administrator, Agricultural Marketing Service.

Nicholas V. Feodoroff, of the School of Engineering of Manhattan College in New York, lectured on the hydraulics of broad-crested weirs at the Technological University in Delft, Holland, during June.

Martin Lessen, professor of applied mechanics and chairman of the Division of Engineering Mechanics at the University of Pennsylvania, will become chairman of the mechanical engineering department of the Univer-

sity of Rochester in September. **Helmut D. Weymann**, assistant research professor at the Institute for Fluid Dynamics and Applied Mathematics of the University of Maryland, has been named associate professor of mechanical engineering at Rochester.

John Gordon Torrey, associate professor of botany at the University of California, Berkeley, became professor of botany at Harvard University on 1 July.

Allan M. Butler and **Felix G. Fleischner** will retire from the faculty of medicine and from their hospital positions at Harvard University, on 31 August. Butler, chief of the Children's Medical Service at Massachusetts General Hospital, will become professor of pediatrics, emeritus; Fleischner, radiologist-in-chief at the Beth Israel Hospital, will become clinical professor of radiology, emeritus.

Six specialists in polar exploration and research shared the first incentive award of the National Science Foundation. The award was made to the following in recognition of their efforts in administering the foundation's post-IGY program in the Antarctic.

Henry S. Francis, Jr., executive assistant to the chief scientist, Antarctic Research Program.

Thomas O. Jones, head of the chemistry department of Haverford College, Haverford, Pa.

Kendall N. Moulton, administrator in the Antarctic for the foundation and for the Polar Operations Project of the U.S. Weather Bureau.

Philip M. Smith, foundation representative on the Bellinghausen Sea penetration by Navy ships in the Antarctic.

George R. Toney, program officer with the U.S. National Committee for the IGY.

Mortimer D. Turner, geological researcher and scientific program planner for antarctic research.

Gustave J. Dammin, professor of pathology at the Harvard Medical School and director of the commission on parasitic diseases of the Armed Forces Epidemiological Board, became president of the board on 1 July. **Harry Most**, professor and chairman of the department of preventive medicine of New York University's School of Medicine succeeded him as director of the commission.

Robert W. Cahn, a metallurgist at the University of Birmingham (England), has been named visiting professor of physics at Temple University, Philadelphia. Cahn will conduct a seminar for graduate students and will also collaborate with **Ralph Feder**, research physicist at Frankford Arsenal's Pitman-Dunn Laboratories, on a metal alloy project.

Edwin E. Moise, professor of mathematics at the University of Michigan, has been appointed the James Bryant Conant professor of education and mathematics at Harvard University.

Rudolph L. Minkowski, astronomer at Mt. Wilson and Palomar observatories, retired on 1 July after 25 years as a member of the two staffs. His recent research has centered on attempts to locate optically objects in space that emit radio waves. Minkowski, who had over-all charge of the Palomar Sky Survey, is a member of the National Academy of Sciences. In the fall he will be visiting professor of astronomy at the University of Wisconsin, Madison.

Henry W. Harris, chief of medical service at the Veterans Administration Hospital in Salt Lake City, will become professor and chairman of the department of medicine at the Women's Medical College of Pennsylvania on 1 September.

George P. Vennart, assistant professor of pathology at Columbia University, is now associate professor of pathology in the School of Medicine of the University of North Carolina.

Ralph M. Dreger, director of the Duval County (Fla.) Child Guidance and Speech Correction Clinic, has been named professor of psychology at Jacksonville University.

Chauncey G. Goodchild, parasitologist and chairman of the department of biology at Emory University in Atlanta, has been appointed Charles Howard Candler professor of biology at Emory.

Frank H. Westheimer, organic chemist and chairman of the chemistry department at Harvard University, became Morris Loeb professor of chemistry on 1 July. Westheimer succeeded **R. B. Woodward,** who has been named Donner professor of science.

Henry B. Linford, professor of chemical engineering at Columbia University, has been named to receive the 1960 Edward Goodrich Acheson gold medal and $1000 prize of the Electrochemical Society.

Douglas M. Surgenor, assistant professor of biological chemistry at Harvard Medical School, has been appointed professor and head of the department of biochemistry at the School of Medicine, University of Buffalo.

Esther M. Conwell, physicist at the General Telephone and Electronics Laboratories in Bayside, N.Y., received the achievement award of the Society of Women Engineers at its 1960 convention in Seattle. She was cited for her solid-state research, which began in 1943 when she worked out the theory of scattering of electrons by ionized impurities with Victor F. Weiskopf.

Recent Deaths

Hal T. Beans, Palisades, N.J.; 83; professor emeritus of chemistry at Columbia University; 8 July.

Hugh H. Bennett, Burlington, N.C.; 79; former chief of the U.S. Soil Conservation Service; conservation pioneer who retired in 1952 after 50 years of government service; 7 July.

James E. Church, Reno, Nev.; 90; internationally known meteorologist and professor at the University of Nevada; originator of snow survey techniques and the inventor of the snow sampler; late 1959.

Carroll E. Cox, College Park, Md.; 49; professor of plant pathology, department of botany, University of Maryland; researcher and writer on the mechanism of action of fungicides; 24 June.

Eric Ellenbogen, Marseilles, France; 39; associate professor of biochemistry in the Graduate School of Public Health, University of Pittsburgh; on leave, 1959–60, to conduct polypeptide research at the Weizmann Institute, Rehovoth, Israel; 29 May.

Wilfred H. Manwaring, Palo Alto, Calif.; 88; professor emeritus of bacteriology and experimental pathology at the Stanford University School of Medicine; 3 July.

Erratum: In column 1 of Table 1 of the report "Osmotic pressure and aqueous humor formation in dogfish" by R. F. Doolittle, C. Thomas, and W. Stone, Jr. [*Science* **132**, 36 (1960)], the parenthetical statement after osmotic pressure should have been milliosmoles instead of mm-Hg.

Book Reviews

1600 Pennsylvania Avenue. Presidents and the people, 1929-1959. Walter Johnson. Little, Brown, Boston, Mass., 1960. x + 390 pp. $6.

Presidential Power. The politics of leadership. Richard E. Neustadt. Wiley, New York, 1960. xii + 224 pp. $5.95.

The President's Cabinet. An analysis in the period from Wilson to Eisenhower. Richard F. Fenno, Jr., Harvard University Press, Cambridge, Mass., 1959. xii + 327 pp. $5.50.

Facts about the Presidents. A compilation of biographical and historical data. Joseph Nathan Kane. H. W. Wilson, New York, 1959. 348 pp. $6.

It is probable that we in the United States are at the beginning of a serious debate concerning the structure and functions of our government. It is quite clear—even if nothing else is—from the development of the discussion so far, that none of its branches is satisfactorily organized for proper functioning. The bland assertion by politicians, who are more declarative than informed, that it is the greatest government on earth and so on and so on, is denied by every careful study that is published. We have before us here several of these studies. No one can read them with any care and continue to be complacent about the situation.

It is natural, this being a Presidential year, that political scientists and publishers should have arranged their schedules so that the current books—and articles—should capitalize on the interest incident to the election. So far this year, I have counted no less than a dozen books, and even more articles, dealing with the Presidency. Those which are not merely eye-catchers express a deep concern about the state of the Presidency. But it is evident that this is part of a larger uneasiness about the whole system subjected to the pressures of the atomic age.

The Presidency, as its assessors look back over the years, has had, out of 33 different incumbents, not more than six or seven who are rated now as being really competent for the duties of the office. [See L. Koenig, coauthor with E. S. Corwin of *The Presidency Today* (New York University Press, 1956), whose latest book, *The Invisible Presidency* (Rinehart, 1959), is an account of several of the most notable "Kitchen Cabinets" and confidential agents, including those of President Eisenhower.] This is a frightening fact. The possibility that some crisis may find in the White House another such as Buchanan, who was there when the nation was splitting in two, is all too likely. This points to a selection process that must be defective.

But there is also the fact that the nation is now several times larger than it was in 1860, and many times more complex. Also, its relations with other powers are infinitely more delicate. It has assumed vast responsibilities for productive facilities, for the welfare of its citizens, and for the security of other noncommunist nations. And the President is looked to as the chief counsellor in all these matters. That any one man can accomplish all that the Presidency is supposed to be responsible for in these times is altogether beyond reason. And the truth is that he does not accomplish it satisfactorily. Many of his duties are delegated to nonelected officials, many have gone to so-called independent agencies which have no place whatever in the American constitutional system, and, unhappily, many are neglected or lost in the bureaucratic complexity of the expanded office. That office has grown from one of a few hundred members, 20 years ago, to one of several thousand members—uncountable exactly because many of them are loans from the Departments, and because many duties that belong to the office are often shunted to the Departments themselves.

Before going on to consider the Presidency itself, let me say that the other branches are, if we read the critical literature, in no better case. The Congress has consented to a good deal of *Executive* reform, but it has not been willing to seek reform itself. And when it has made a gesture toward change—for example, in the La Follette-Monroney Act of 1946—the provisions made into law have been almost completely ignored by succeeding legislatures. The faults complained of by Woodrow Wilson have not been overcome. Committees are still in control; their powerful leading members can smother legislation almost without check, and their investigative procedures often come under severe criticism. But the most serious failure is that of leadership. It is practically impossible for a program to originate in the legislative branch; and the tendency to resist those originating in the Executive, bad enough at any time, is made worse when, as has so often been the case in late years, the Executive belongs to one party and the congressional majority to another.

The indictment extends to the third branch, the Judiciary. The Supreme Court has proceeded more and more boldly—most boldly of all (which seems something of a paradox) when there has been a "liberal" majority—to usurp the law-making function. Sanctioning, as it has, the intrusion into the governmental structure of the independent agencies, it has proceeded to make these agencies responsible to the Court by refusing the President the right to dismiss those he appoints but retaining for itself the right to approve or disapprove agency decisions. It has made judicial review into a principle upon which judicial supremacy has been built. And this astounding *tour de force* is no longer questioned by those that it most effects. Most astounding of all, the Court had the audacity to tell President Truman what constituted the Doctrine of Necessity. He allowed himself to be instructed in the steel seizure instance (1952). And from now on no President will know what he may and may not do when the nation is confronted with crisis or disaster.

All this is not as dangerous to democracy, perhaps, as the critics insist. The nation has not succumbed either to governmental confusion or to dangers from without. And there is a certain virtue in passing through a period of failure and self-doubt, such as the present, if it results in soul-searching and, in the end, reasoned reform. The strictures of the political scientists, moreover, are turning from negative criticisms to positive suggestions. They have not yet become very bold in constitutional terms, but that would seem to be

the next turn of the debate now going on. It may be that, despite appearances, revisions will antedate the crisis that would result in breakdown.

The present focus on the Presidency has resulted in the books before us. Walter Johnson writes a history of recent times with the focus on the Presidency as the center of policy making; Richard Fenno writes of the President and his Cabinet; Richard Neustadt analyses the Presidential power together with the politics of leadership; and Joseph Kane furnishes a rich display of data from which we can learn what past Presidents have been like.

Johnson's *1600 Pennsylvania Avenue* is a historian's, rather than a political scientist's, view of the Presidency. Characteristically, he considers the events of three Administrations—Roosevelt, Truman, and Eisenhower, with looks backward at that of Hoover—for the lessons to be learned. He finds that Roosevelt and Truman accomplished much, that Hoover floundered, and that Eisenhower has almost a genius for missing his opportunities. But Roosevelt had a tendency, he says, to deviousness, and Truman never lost the traits of the county politician. These are judgments about the Presidents themselves. But his interest does not extend to questioning the adequacy of the office itself or of the system of which it is part. He is, in other words content to review the achievement of each, measured by the immense demands of the times in which he lived. It is true that these were times of transformation and that during some of the crises incident to the times the occupant of the White House seemed caught up in cyclonic winds far beyond his power to subdue. But it is still possible to make some estimate of their effort, and that is what Johnson has done. As a historian, he is sometimes more interested in the events themselves than in the President about whom the events centered, but the only criticism to be made of this preoccupation is that he chose to call his book by a title that seems to indicate that it is about the Presidency. His brief history of some 30 years is that of one who lived through and had some part in the years, and that of one, too, who has a facility for summarization and exposition. 1600 Pennsylvania Avenue was the scene of dramatic decisions, the center of national management; but whether its decisions could have been more wisely made or whether its affairs could have been better managed, we do not learn.

Something about this emerges from Fenno's study of the Cabinet. Anyone who goes seriously into the situation of this body in the American governmental system is certain to emerge more sophisticated but also more despairing than when he began. Fenno is no exception. He does, however, recognize that he is dealing not just with the relationship of a group of men to their chief and with ways to organize that relationship more effectively. His main concern has to be with some fundamentals such as whether the President is to be made stronger or weaker, whether the government itself is to move toward unity or is to keep its essentially pluralistic character, whether administrative management or policy making is the first Presidential duty.

In a sense the Cabinet has no existence; in another it has to be recognized as a persistent institution. It has no constitutional authorization; it is completely subordinate to the President, since all its members are his heads of Departments, and he is after all, Chief Executive. But the Congress has always designated Department heads for duties independent of Presidential control, and the tendency to do this has not lessened in recent years. Therefore when the Cabinet members are used as a Council for advice, the President has around his table a group some of whom may be disposed *not* to take directions from him even in administrative matters. Their feeling of independence, because they are the representatives in government of vast interests—finance, agriculture, labor, business, and so on—may outweigh the loyalty that the President may expect of them.

This is not true—or is much less true —of two of their number, the Secretary of State and the Attorney General. These are, by their situation, closely identified with the President. The others have demanding administrative duties which make it impossible for them to become well informed about matters outside their own provinces, and their ties to special interests very often lessen their value as advisers. As a matter of fact, it has sometimes been suggested that of all possible groups of men, these Department heads, with the two exceptions, are the least likely to give the President good counsel.

Cabinet meetings have a tendency to become very nearly farcical. Matters of high concern are seldom discussed because the number of people is too large for intimacy and because so many with no special competence are present; matters of departmental concern are not spoken of because Secretaries dislike sharing their troubles with other officials. Still it always seems to be a comforting assumption that the President is surrounded by statesmen of high caliber, who will give his decisions weight and certainty. However many disclosures are made showing that the fact is otherwise, the myth persists. Presidents, realizing that Cabinet meetings are so often a costly waste of time, have in at least two instances attempted to discontinue them altogether, and in many others have reduced their frequency. But public disapproval has always had to be taken into account, and more or less regular meetings have been kept up.

Political scientists have treated this governmental anomaly with caution. None, I believe, has advocated discontinuance of its advisory function, but some have suggested a series of subcabinet organizations of a more nearly functional nature. Still others, sharing the public feeling that there ought to be a Presidential Council, have wanted to establish a special Cabinet secretariat with the duty of regularizing and upgrading the advisory function. This seemed to President Eisenhower, with his military background, a necessary change, and it was made.

It has not been successful. No amount of briefing or following-up could make Cabinet members wiser than they were before; neither could it reduce the work load of the Departments. Further, it could not change their desire to have private talks with the President himself, rather than with a large group. The whole matter will again be open for recasting by the next President.

All this is fully and adequately gone into by Fenno. To sharpen several of the problems, he has related illustrative incidents. There are many accounts of these meetings available in the notes of those attending them. Sometimes they have been recounted by several participants. They are amazingly uniform in their deprecation of the Council idea. But it still persists.

For a candid account of a most elusive subject, seldom before approached with such extensive use of anthropological and psychological critiques, political science is indebted to the author.

Neustadt's study is directed to a quite different problem. He is interested in what a President must do to be successful in the circumstances of the present. He is concerned that so much depends on the expertness of the one man who disposes of the Presidential power. Here again, there is in operation a powerful myth which is respected even by those

who know it for what it is. Americans elect Presidents in political campaigns which are heated partisan battles, and the man who is elected is recognized as the head of his party. Yet he is expected instantly, once he is inaugurated, to be "above politics." It is elementary that it cannot be had both ways; yet every President strains to make the impossible straddle. Some convey the impression that they have thus risen above their origins; but if they actually have made such an attempt, they almost certainly have lost the power to lead. They cannot exert the discipline needed by the amorphous and often rebellious Congress without the use of party means. And if they do not lead, they disappoint the expectations of the electorate and fade into history as failures.

Using the experience of recent Presidents, Neustadt illustrates the Presidential requirements and shows how very difficult it is to find an individual who can meet them. Such an individual is something of a clerk, which is to say that he must work within an elaborate apparatus that can be expected to have an almost immovable inertia; yet he must try to find the means to move it. He does not have a separated power; he has a shared power; and the sharing is almost the most important characteristic of his office. Yet he can, if, as Woodrow Wilson said, he is man enough, find the leverage to alter the course of events, furthering, as he must believe, the best interests of the nation of which he is the head and symbol. So Mr. Eisenhower may be a Republican, he may be strongly disapproved of by many Americans for one or another reason, and he may be made the subject of caustic comment. But when the head of another State ridicules him, the outrage that seizes Americans is explosive. He is their man.

It is this potential support that a President must know how to gather and dispose for the nation's good. This is his central duty. But there have been many Presidents who have not known how to perform it, and it is a matter for despair to suggest any reasonable way of choosing individuals who will be so gifted.

If the last few Administrations are examined, as Neustadt examines them, none provides a perfect case of Presidential competence. But there are instances of remarkable success as well as others of abysmal failure. The successes, like the failures, are almost frighteningly connected with personal circumstances. Roosevelt was superb in the first days of the New Deal, but in 1937 he handled the Supreme Court battle as though he had never learned anything about leadership in a democracy. Eisenhower's indifferences to many problems has seemed to originate in a tiredness which grew as his time in office lengthened. Truman's Marshall Plan and Point Four programs were vigorous examples of leadership, but he allowed relations with the Soviet Union to fall into the state where exchanges became hardly more than slanging matches that went on for weary year after weary year while the crisis of atomic armament deepened.

We are led, although this is to go beyond the Neustadt suggestions, to ask whether something more drastic is not needed. That the President may be a hero to his people does not make it less likely that he will fail because he cannot do all that is expected of him. For almost a generation now, the attempts to bolster his performance with administrative aids have been the favored approach to the admittedly serious problem. This elaboration of machinery has tended to conceal the essential truth that a President cannot be changed by assistance. He can be aided by it, but it will not make him any wiser. It will not change the fact that he is one single, often elderly, individual and that he is sometimes tired or ill.

A book which is thoughtful and considerate, as Neustadt's is, makes the conclusion almost inevitable that we have been looking in the wrong direction, trying the wrong remedies, and that presently we shall need to re-examine our situation in much the same way as it was re-examined in Philadelphia in 1787. When we do, we are not likely to conclude that, for modern America, the institutions of a small emerging seacoast power are altogether adequate, more than a century and a half later, for a continental nation. Indeed, if the proceedings are conducted in the spirit of the Convention we are certain to find the institutions insufficient, just as the forefathers found the ones they were revising insufficient.

As a kind of addendum here, of interest to those who are finding themselves at a loss for many of the facts needed to judge how the Presidency has served us, and who wonder what the uniformities are in the processes of election or even in Presidential performances, a most useful compendium has become available in Joseph Nathan Kane's *Facts About the Presidents*. It will certainly be found on every political scientist's desk from now on. Careful searching has turned up most useful comparative data about origins, affiliations, performance, and many other relevant matters. They are all here. There are no judgments, simply facts. It is a relief to have them, for once, in uncolored form.

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The Special Theory of Relativity. J. Aharoni. Oxford University Press, New York, 1959. viii + 285 pp. Illus. $7.20

This book is a technical introduction to the special theory of relativity, written with considerable emphasis on the formal aspects of the subject, and quite apparently aimed at British students of physics and of applied mathematics, whose backgrounds and attitudes vary somewhat from the backgrounds and attitudes met with, on the average, on American campuses. Although the book covers more or less the same ground as any other competent text, the slight change in approach makes for interesting reading.

The chapters are devoted in turn to the following topics: kinematics of the special theory and of the Lorentz group; three-dimensional tensors; Maxwell's theory in tensor formulation; general field theory (nonquantum, to be sure); relativistic particle dynamics and hydrodynamics; and spinors (treated in the van der Waerden formalism). An appendix is concerned specifically with the propagation of light and generally with electromagnetic waves. The author introduces group-theoretical concepts to the extent that he discusses tensors and spinors as representations of the orthogonal group and the Lorentz group and gives some attention to questions of irreducibility of representations. Three-dimensional and four-dimensional notation are used side by side. As far as I can tell, the explanations are straightforward and there are no errors in either the physics or the mathematics. It is quite obvious that the author is considerably more knowledgeable than might be assumed by the neophyte who is favorably impressed by the simplicity of presentation. Though quantum theory is only hinted at, much of the book's work is preparatory to the study of quantum field theory.

Aharoni's book could be placed, as a challenge, in the hands of a first-year graduate student, although such a student would probably need some help in studying it.

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Plant Growth Substances. L. J. Audus. Leonard Hill, London; Interscience, New York, ed. 2, 1959. xxii + 553 pp. Illus. + plates. $10.

Audus has presented, in readable detail, the background of the nature of plant growth from cell division to the nutritional and hormonal factors affecting development. He has included a discussion of the general physiology of natural auxins, including assay methods, isolation, and identification, and a section on the chemistry of natural and synthetic auxins, relating to structure and activity. From this orientation in fundamental principles, Audus proceeds to a comprehensive coverage and classification of auxins as general growth stimulators and inhibitors, initiators of rooting, stimulators of fruit development, and selective weed killers. He defines their role in flowering and reproduction and their influence in tissue differentiation. The appendixes delineating auxin-treatment responses of plant species from all over the world are a unique feature.

This edition includes material on the advances made since 1953 in the field of plant growth substances and sections on recently isolated and newly synthesized growth substances, the separation and identification of natural plant growth substances, and on new and varied applications which have been tried and evaluated. A chapter on the mechanism of action of auxins is a significant addition, and this, taken with the comprehensive discussions concerning the physiological action of other classes of growth regulators given in succeeding chapters, offers one of the most complete and up-to-date surveys of this kind on the subject.

This book should be accepted with interest and pleasure by the intelligent layman who engages in serious reading for a better understanding of the biological responses of the plants in his environment and, more specifically, for an understanding of the factors involved in regulating these response phenomena. It is not, as Audus points out, a manual for the specific treatment of growing plants, but rather, a digest of information on the control of plant development by growth-regulating substances. While the professional chemist or physiologist will not consider it a necessary acquisition for his technical library, the student of agriculture or horticulture will certainly find it a most useful reference source. The work contains, in logically presented order, a wealth of information, possibly to the degree that it encompasses too much. It is indeed difficult to collate in one volume material which is intelligible and appealing to the layman and which, by reason of its technical information, is also valuable to the specialist.

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The United States in the World Arena. An essay in recent history. W. W. Rostow. Harper, New York, 1960. xxii + 568 pp. $8.75.

W. W. Rostow specializes in the Large View of history. His particular mode of contributing lies in fashioning new points of view from which to analyze past events, present trends, and future prospects. This he did admirably and neatly in his recent book, *The Stages of Economic Growth*. Unfortunately not so much can be said for the present volume.

The author sets about to analyze in one fell swoop the military and diplomatic events of World War II and the Truman and Eisenhower administrations to see how these events fit his conception of America's national interest. He invents a useful notion, "national style" ("that is, the typically American way of dealing with the nation's environment"), as a means of tying together his unwieldy material and relating it to his major theme. He finds serious deficiencies in the national style and suggests numerous reforms which he thinks are urgently needed in view of the political and technological changes which are going on in the world.

The persuasiveness of Rostow's critique depends ultimately on the persuasiveness of his concept of America's national interest. In company with most critics of public policy today, he holds that our national interest has a dimension over and above simple considerations of geography. Thus, while he says that the United States, "a continental island off the greater land mass of Eurasia," must prevent any single power or groups of powers, hostile or potentially hostile to itself, from dominating that area, he goes further and says that our national interest demands that "the societies of Eurasia develop along lines broadly consistent with the nation's own ideology."

So far, so good, but the trouble is that Rostow is quite unable to articulate anything worthy of being called "the nation's own ideology." Leaving aside the question of whether or not ideology is the right word, he describes the dynamic element of America's national interest in humanistic terms, and perhaps this is why his essay at this crucial point lacks both precision and good philosophical syntax. It remains to be shown that the language of humanism permits the asking of the really important questions which must be answered if one is to articulate our national interest in its dynamic dimension—questions such as "What beliefs make real and rational our concern about the future welfare of other nations and other races?" A simple benevolence toward the individuals who make up the human race is no substitute for philosophy any more than it is a substitute for national interest. Rostow is at pains to avoid the latter pitfall but does not show that he has escaped the former.

But if the author is not successful in coming up with a persuasive and practical definition of the dynamic element in our national interest, he is very successful in illustrating the perils of trying to get along without such a definition. The lack of such a definition, according to Rostow, has been a distinguishing characteristic of our national style in military and diplomatic policy since the beginning of World War II. (Earlier, he says, we alternated between the geopolitical ideas of Admiral Mahan and the idealism of Woodrow Wilson when we were not content with moralistic isolationism, which, he contends, was rarely so.)

The author finds that our national style in military and diplomatic policy came off a poor second to that of the British in World War II and to that of the Russians in the postwar period. As stylists, Roosevelt and Truman get better marks than Eisenhower (whose administration the author finds consistent-

ly "sluggish"), but none of them get very high marks. Of World War II Rostow writes: "the American national interest (in contrast to the British) was a matter of unresolved national debate, if not of private personal opinion . . . [the military] resisted systematically the application of diplomatic and political criteria to their military plans; and Roosevelt supported them." And of the postwar years he writes (specifically in the case of the aftermath of the Korean crisis): "The nation continued in its familiar style to institutionalize its emergency response to the last crisis." The picture is of the trouble shooter absorbed solely with the *immediate* source of trouble.

The author's judgment of recent events, while on the whole persuasive, is sometimes unnecessarily lugubrious, especially in view of the fact that he professes to be something of an optimist. In particular he dismisses, with an almost cavalier treatment, the innovations in national style which came, albeit briefly, with the Marshall Plan. Perhaps more than any other policy in the postwar period, the Marshall Plan brought to the fore in Washington men with a highly developed and practical sense of the dynamic element in America's national interest. It is most surprising that none of these men, not even Paul Hoffman, rates so much as a mention in this long volume. The author feels constrained to rest the major part of his judgment of the Marshall Plan on the statement that it did not move Western Europe "radically" toward unity. Perhaps the movement wasn't radical, but it was certainly substantial. Just to cite two institutional innovations: the Schumann Plan was a direct consequence of Hoffman's diplomacy, and the European Payments Union was quite literally made in Washington. Why the author chose to pass up this very apt illustration of the kind of national style he so obviously advocates is a mystery.

Rostow is more constructive and more persuasive in the final section of the book when he looks ahead. He sees a future in which there will be a considerable "diffusion of power" among the nations of the world as a result of the spread of technology and the rising political aspirations of formerly backward nations, and he draws up an agenda of problems which will face this country as a consequence. He raises the fundamental question of whether and how the deficiencies in our national style, as they relate to military and diplomatic policy, can be corrected. Specifically, he isolates the many-sided problem of policy innovations in a democracy, a subject to which one hopes he may return in the future in a more leisurely book.

One cannot help but admire the author's courage in being willing to set out his themes on such a big canvas. One could only wish he had picked fewer themes and had related his detail more closely to them. Perhaps if he had done so, his concept of national interest in its dynamic element could have been made clearer, and he would sound less like an efficiency expert who is not always clear just what it is he is trying to be efficient about.

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Science in Progress. Eleventh series. Hugh Taylor, Ed. Yale University Press, New Haven, Conn., 1960. xii + 379 pp. Illus. $7.50.

The Sigma Xi-RESA lecture series needs no introduction to the scientific community; this volume, however, seems a bit stronger in earth sciences (as they are fashionably called nowadays) than in some other disciplines, although there are excellent lectures on behavior, viruses, and other aspects of biology. The price of this volume is a bit steep, and one wonders if wider circulation might be achieved if the publishers were to issue it in paperback form at perhaps a third of the price.

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New Books

Mathematics, Physical Sciences, and Engineering

Nevanlinna, R., *et al. Analytic Functions*. Princeton Univ. Press, Princeton, N.J., 1960. 204 pp. $5. This volume, No. 24 in the Princeton Mathematical Series (Marston Morse and A. W. Tucker, Eds.), contains the principal addresses delivered at the conference on analytic functions held in September 1957 at the Institute for Advanced Study. Contributors are R. Nevanlinna, H. Behnke, H. Grauert, L. V. Ahlfors, D. C. Spencer, L. Bers, K. Kodaira, M. Heins, and J. A. Jenkins.

Newell, Homer E., Jr. *Window in the Sky*. The story of our upper atmosphere. McGraw-Hill, New York, 1960. 116 pp. $2.75.

O'Sullivan, J. J., Ed. *Proceedings of the Second Protective Construction Symposium* (deep underground construction). vols. 1 and 2. RAND Corporation, Santa Monica, Calif., 1959. 988 pp. Papers stress the design and construction of underground facilities to resist the effects of nuclear weapons. Copies of the report are available for use at deposit libraries, but the report is not for sale.

Parzen, Emanuel. *Modern Probability Theory and Its Applications*. Wiley, New York, 1960. 479 pp. $10.75.

Pugh, Emerson M., and Emerson W. Pugh. *Principles of Electricity and Magnetism*. Addison-Wesley, Reading, Mass., 1960. 441 pp. $8.75.

Reid, Charles E. *Principles of Chemical Thermodynamics*. Reinhold, New York, 1960. 318 pp. College edition, $6; trade edition, $7.80. "Intended as an introductory thermodynamics course for graduate students in chemistry . . . not beyond the ability of qualified undergraduates."

Roberts, C. Sheldon. *Magnesium and Its Alloys*. Wiley, New York, 1960. 241 pp. $9.

Rosen, Milton J., and Henry A. Goldsmith. *Systematic Analysis of Surface-Active Agents*. vol. 12 of *Chemical Analysis*. Interscience, New York, 1960. 439 pp. $13.50.

Simon, Albert. *An Introduction to Thermonuclear Research*. A series of lectures given in 1955. Pergamon Press, New York, 1959. 191 pp. $5.50.

Sneddon, I. N., and R. Hill. *Progress in Solid Mechanics*. North-Holland, Amsterdam; Interscience, New York, 1960. 460 pp. $15.50.

Steinberg, J. L., and J. Lequeux. *Radioastronomie*. Dunod, Paris, 1960. 305 pp. NF. 19.

Thwaites, Bryan, Ed. *Incompressible Aerodynamics*. An account of the theory and observation of the steady flow of incompressible fluid past aerofoils, wings, and other bodies. Oxford Univ. Press, New York, 1960. 656 pp. $12.

Vasicek, A. *Optics of Thin Films*. North-Holland, Amsterdam; Interscience, New York, 1960. 416 pp. $12.50.

Weissberger, Arnold, Ed. *Physical Methods of Organic Chemistry*. pt. 2 of vol. 1 of *Technique of Organic Chemistry*. Interscience, New York, ed. 3, 1960. 924 pp. $24.50. From the preface: New topics added include chapters on automatic control, automatic recording, weighing, determination of particle size and molecular weight, x-ray microscopy, the Kerr effect, determination of the Faraday effect, nuclear magnetic resonance, paramagnetic resonance absorption, determination of transference numbers, and controlled-potential electrolysis.

Zechmeister, L., Ed. *Progress in the Chemistry of Organic Natural Products*. vol. 17. Springer, Berlin, 1959. 525 pp. $19.80. Contributors include K. Venkataraman, H. H. Inhoffen, K. Irmscher, B. B. Stowe, and P. H. Abelson.

Ziman, J. M. *Electrons and Phonons*. The theory of transport phenomena in solids. Oxford Univ. Press, New York, 1960. 568 pp. $13.45.

Reports

First Natural Occurrence of Coesite

Abstract. Coesite, the high-pressure polymorph of SiO_2, hitherto known only as a synthetic compound, is identified as an abundant mineral in sheared Coconino sandstone at Meteor Crater, Arizona. This natural occurrence has important bearing on the recognition of meteorite impact craters in quartz-bearing geologic formations.

We report in this communication the discovery of the first natural occurrence of coesite, the high-pressure polymorph of silica. Synthesis of coesite was successfully performed by Coes (*1*) and determinations of the stability fields of quartz and coesite have been published by MacDonald, Dachille and Roy, and Boyd and England (*2, 3*). In recent years the search for natural occurrences of coesite by geologists and mineralogists, including our examination of quartz-bearing rocks subjected to shock induced by hypervelocity impact and nuclear explosion, proved unsuccessful. The identification of coesite in samples of sheared Coconino sandstone collected from Meteor Crater, Arizona, culminates this determined search.

Meteor Crater is a bowl-shaped depression surrounded by a low rim (*4*). Upturned strata of the Coconino sandstone, Toroweap formation, and Kaibab limestone, all of Permian age, and the Moenkopi formation of Triassic age are exposed in the walls of the crater (*5*). The floor of the crater is underlain by a succession of Pleistocene and Recent talus, alluvial deposits, and lake beds resting on a layer of mixed debris up to 30 feet thick, which in turn overlies a deep breccia lens up to 600 feet thick. The rim of the crater is underlain by a complex sequence of Quaternary debris and alluvium resting on disturbed Moenkopi and Kaibab strata.

The relatively undamaged Coconino sandstone in the walls of the crater is a white, fine-grained saccharoidal cross-bedded quartzose sandstone. Coesite occurs chiefly in compressed and sheared Coconino sandstone (Fig. 1), which constitutes a major part of the layer of mixed debris under the crater floor and is dispersed in the underlying breccia lens. Coesite-bearing sandstone fragments are also a major constituent of drill cuttings from near the base of the lens, 600 to 650 feet beneath the crater floor. Some coesite-bearing fragments of sandstone are also found in Pleistocene and Recent alluvium on the rim of the crater, mainly in association with sintered rocks. Coesite also is a subordinate constituent of sandstone that has largely been converted to glass (lechatelierite). The glassy fragments form large frothy chunks in the base of the Pleistocene lake beds in the crater floor, are also found as lapilli and bombs incorporated in the alluvium on the crater rim, and are dispersed as finer fragments in the mixed debris and breccia under the crater. In some samples from this crater, fine-grained coesite had previously been thought to be glass or partially devitrified glass by Merrill (*6*), Rogers (*7*), and Shoemaker (*5, 8*). Coesite occurs in the fine-grained, nearly isotropic, matrix in which the subrounded fractured quartz grains are imbedded (see Fig. 2).

The identification of natural coesite is based on its x-ray powder diffraction pattern, its optical properties, and the spectrographic analysis of a purified sample. Figure 3*A* is the x-ray powder diffraction pattern of coesite concentrated from sheared Coconino sandstone. It is identical to the x-ray powder diffraction pattern of coesite (Fig. 3*B*) synthesized by F. R. Boyd of the Geophysical Laboratory. The extra lines shown in Fig. 3*A* are primarily those of quartz, which are present as impurity in the natural coesite.

Under the microscope coesite appears in irregular grains or vaguely rectangular grains 5 to more than 50 μ in size (Fig. 4). The mineral has a mean index of refraction of 1.595 and a very low birefringence.

A chemically concentrated sample shown by x-ray pattern to contain essentially coesite, with some quartz, was spectrographically analyzed. The sample contains more than 99 percent silica and less than 1 percent of other cations. This analysis substantiates the conclusion that the mineral is SiO_2.

The occurrence of coesite at Meteor Crater has significant implications for the fields of both geology and physics. First, it demonstrates that the polymorphic transformation from quartz to coesite may occur under shocks generated by meteorite impact. It is too early at this stage to say what the pressure and temperature conditions were when coesite was formed by impact at the Meteor Crater. The presence of coesite indicates pressures in excess of 20 kilobars. The additional presence of silica glass may indicate temperatures, at least locally, of about 1000°C or higher. DeCarli and Jamieson (*9*) failed to find coesite in single quartz crystals shock-loaded to pressures up to 800 kilobars, and one of us (E.M.S.) has failed to find coesite in quartose media shocked to similar high pressures by experimental hypervelocity impact and by nuclear explosion. These results suggest that the transformation is too sluggish to take place in shock waves of very short duration, and that the sluggish quartz-coesite transformation may occur some distance behind the shock front in a shock wave of much longer duration, such as was probably produced by impact at Meteor Crater (*5*).

Second, the occurrence of coesite at Meteor Crater suggests that the presence of coesite may afford a criterion for the recognition of other impact craters on the earth and perhaps ultimately on the moon and other planets. According to the data of Boyd and England (*3*) coesite probably cannot form at pressures of less than about 20 kilobars—a pressure not likely to be reached near the surface of a planet for a long enough period of time for coesite formation except by the mechanism of impact. However, coesite must persist in the low-pressure regime for a significant period of geologic time if it is to be a useful tool in the recognition of ancient geologic structures.

Third, the discovery of coesite in a natural environment puts it in the category of a true mineral (*10*).

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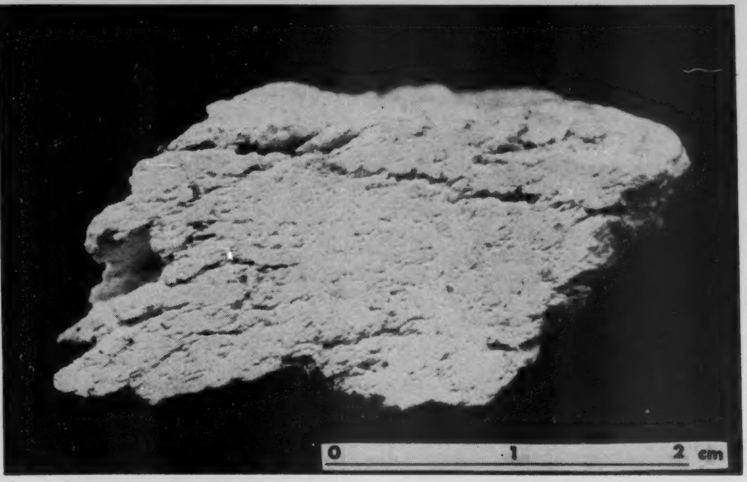
Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper.

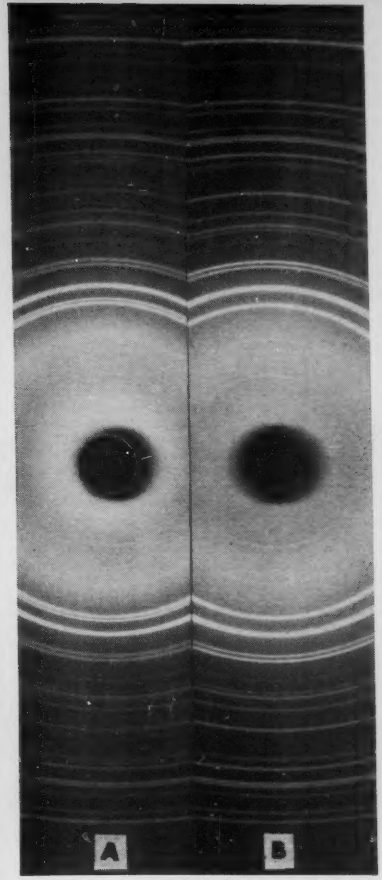
Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

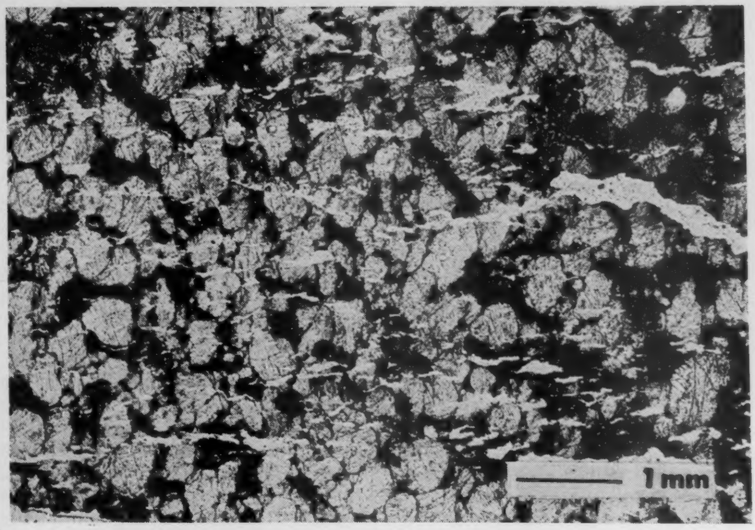
Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* **125**, 16 (1957)].







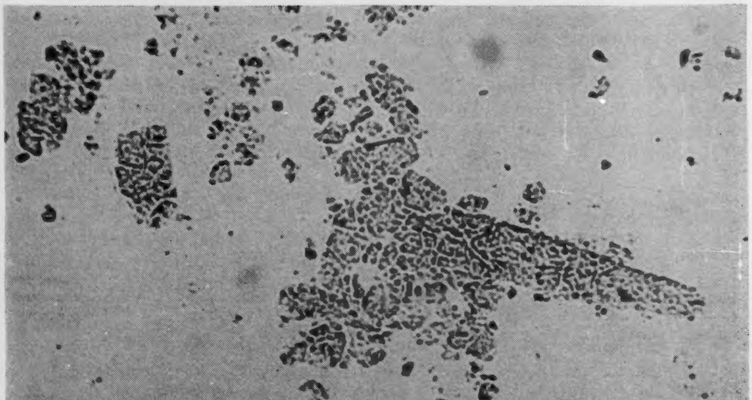


Fig. 1 (top, left). Sheared Coconino sandstone. Fig. 2 (middle, left). Photomicrograph of sheared Coconino sandstone (plain reflected light). Fractured quartz (gray) in matrix (dark) which contains coesite. Fig. 3 (top, right). (*A*) Natural coesite with minor amounts of quartz; (*B*) synthetic coesite. Fig. 4 (bottom, left). Natural coesite with inclusions of quartz (plain reflected light). The photograph was taken with coesite in 1.540 oil and is slightly out of focus.

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10. We are indebted to the Barringer Crater Company for granting access to its property and for the many courtesies extended during the investigation at Meteor Crater. Specimens of drill cuttings and cores from Meteor Crater were made available by the geology department of Princeton University. We wish also to acknowledge the assistance of our colleagues J. J. Fahey, who helped to chemically concentrate the coesite sample; Harry Bastron, who made the spectrographic analysis; and B. J. Skinner, who aided in x-ray correlations. We are indebted to W. T. Pecora and B. J. Skinner for discussion of the problems and for their constructive criticism of the manuscript. Part of this work was done on behalf of the Division of Research of the Atomic Energy Commission. Publication was authorized by the director of the U.S. Geological Survey.

22 June 1960

Sound Production by the Satinfin Shiner, Notropis analostanus, and Related Fishes

Abstract. Several sounds are produced by minnows. Only one is not of purely mechanical origin, and it is classed as a "biological" sound. This sound is variously produced by males when fighting and chasing as well as during courtship. Females emit a similar sound. Testosterone injections and elevated temperatures result in an increased rate of biological sound emission.

In recent years it has been demonstrated that marine fishes produce a wide variety of sounds, some of which must have a biological function (*1–3*). Little work has been done on freshwater fishes, although aquarists and several European investigators have occasionally heard their sounds (*4, 5*). *Phoxinus laevis,* a cyprinid of Europe, has been studied in detail, but the only reported sound produced by this fish was one caused by the emission of a bubble of air (*5*).

Several kinds of sounds have been recorded from *Notropis analostanus* (*6, 7*). These were a scratchy sound produced when the fish hit the bottom gravel under various conditions, a high-pitched noise when air bubbles were released from the mouth, occasional chewing sounds, and finally one or more sharp knocks produced most frequently during reproductive activities. All except the latter are mechanical sounds, and superficially they do not appear to have any biological function, although they cannot be overlooked as potential stimuli to the fish. The knocks (similar to the sound made when one strikes wood with his knuckle) appeared under conditions that identified them as "biological" sounds. They were produced when the males fought and when the males and females courted, and appeared not to be a sound primarily associated with necessary movements. We follow the use of the terms "biological" and "mechanical" sounds as proposed by M. P. Fish (*1*), although there is reason to believe that the two categories grade into each other on an evolutionary basis, and may soon outlive their usefulness.

The single knocks, made when a male chased and fought with a male, contained frequencies from below 85 cy/sec up to between 2000 and at least 11,000 cy/sec, and lasted between 11 and 60 msec with greater intensities in the lower frequencies, as analyzed with a Kay Sonagraph model recorder. These single knocks were produced rapidly and intensely (40 to 60 msec, tapering to below 12 msec at highest frequencies) when a male chased another male, but they could be united into a very close series (11 to 24 msec, tapering very slightly to below 12 msec at highest frequencies) when two males fought each other. Similarly a purring sound occurred when a male actively courted a female. This appeared to be basically the same sound, but it was emitted more rapidly and less intensely. In all cases the male made these sounds (isolated, fighting a mirror image, and so forth), but isolated females also produced fainter, less frequent knocks than males, so that it was impossible to know which sex made the sound during courtship.

Biological sounds similar to the knocks of *N. analostanus* have been heard in other species of minnows. Occasional knocks were heard when a male chased another male of *Gila* (Clinostomus) *vandoisula* and *Notropis spilopterus,* and a large series of knocks were heard when several to many males chased a female of *Semotilus* (Margariscus) *margarita.*

The structure that produced the "biological" knocks has not been located. The sound was still produced, seemingly unaltered, when various organs were experimentally manipulated as follows: angle of jaws, base of pectoral girdle, pharyngeal arches cut through; operculum, pelvic fins, pectoral fins, anal fin, dorsal fin cut off; the air bladder punctured and removed; and the body cavity injected with petrolatum.

A series of males of *Notropis analostanus,* at the beginning of the breeding season (June and early July), were placed in water at different temperatures (Table 1). The production of sound decreased significantly at the lower temperatures. This fish breeds in water of 20° to 30°C. Individuals injected with testosterone at 25° to 27°C with a 10-hour photoperiod produced many more sounds than fish injected with sesame oil and normal control fish from 5 to 10 days after injection. The activity of those injected with testosterone was considerably greater than that of the control group.

Over the past 30 years many German and Dutch workers have demonstrated that *Phoxinus laevis* and other freshwater fishes are able to hear and that this ability extends into frequencies not heard by nonostariophysid species of fish (*4, 8*). This ability to hear sounds of frequencies up to as high as 7000 cy/sec or more is enhanced by the weberian apparatus which connects the air bladder to the inner ear. However, the only sounds that have been heard from minnows are "nonbiological" sounds such as the chewing sounds made by goldfish and the emission of air from the air bladder of *P. laevis.* This suggested to the German and Dutch workers that the acuity of hear-

Table 1. The range and average number of sounds produced by males of *Notropis analostanus,* kept in 15-gal aquaria with an 18-hour photoperiod at various temperatures, during 5-minute listening periods, in June and July 1959. Three recordings were taken for each of three experiments (average usually based on nine readings), each with four males except for day one where data were available for only two experiments (average based on six readings). Some deaths occurred in one experiment at the highest temperature.

Temp. (°C)	Days after beginning of experiment									
	1		2		3		4		5	
	Range	Av.	Range	Av.	Range	Av.	Range	Av.	Range	Av.
29–30	109–280	231	35–328	176	8–207	102	101–191	157	64–161	121
23–24	27–206	70	12–43	23	14–193	69	18–101	41	11–49	25
18–19	10–69	27	14–213	82	18–129	60	6–100	37	4–96	43
13–14	3–13	5	1–7	4	0–23	6	4–18	9	2–24	11
7–9	0–5	1	0	0	0–3	1	1–6	2	0–3	1

ing in minnows need not be associated with the actual production of behaviorally significant and controllable sounds by the fish. On this basis they concluded that it has developed in response to mechanical and incidental sounds produced by the fish and the environment. From our data, however, it appears that many minnows produce "biological" sounds that can act as stimuli in reproductive activities, although the actual nature of the function of the sound has not been experimentally tested. The sound's association with reproductive activities, and its increase in rate with temperature elevation and injections of testosterone, seem to place the knocks and purrs of *Notropis analostanus* in the class of "biological" sounds. It might be hypothesized that the sound repulses under some conditions (as when two males of *N. analostanus* fight) and attracts under others (as when males of *Gila margarita* follow females to spawn). Hypotheses like these are numerous in the literature. Tavolga's experiments (*2*), which demonstrate that the grunts of the goby attract, and Moulton's playback (*3*) of sea robin calls to sea robins, which resulted in answering back, are the only experiments demonstrating the functions of sounds for fishes, except for occasional startle responses reported by various authors.

The sounds with frequency components as high as 11,000 cy/sec, produced by the cyprinid we studied, contain frequencies which are well fitted to the sensitive hearing ability of ostariophysid fishes. Perhaps this more sensitive hearing has been one of the causes for their success in the fresh waters of the world (over 70 percent of the primary fresh-water fishes of the world are ostariophysids). The statement by Moore and Newman (*9*) that natural noises in fresh waters are so great as to make unlikely the use of any sounds for attraction or repulsion of fish seems unjustified, or at least premature, although it may be true for the salmonids with which they worked. *Notropis analostanus* produces these sounds in fairly rapid and noisy water of small streams where they spawn, but, the sounds are made when the fish are close to each other.

The fresh-water minnows' "biological" sounds, their ease of handling, and the fact that they will go through normal behavior, especially spawning, in the laboratory, make these fish excellent subjects for the study of sound. This is less true for most marine fishes at this time.

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24 February 1960

Avoidance Conditioning and Alcohol Consumption in Rhesus Monkeys

Abstract. Measures of intake of water and of a solution of 20-percent alcohol in water were determined in rhesus monkeys before, during, and after avoidance training. Alcohol consumption increased during, and decreased after, avoidance sessions. Water intake remained the same or decreased during avoidance sessions and stayed at this level after the sessions.

Masserman and Yum (*1*) reported that cats often develop a definite preference for a solution of alcohol in milk, if they are given alcohol during a conflict conditioning procedure. Aside from these data, little is known about the effects of various conditioning procedures on alcohol intake.

In the experiment reported here we investigated the effects of an avoidance conditioning procedure (*2*) on the alcohol consumption of rhesus monkeys. Avoidance conditioning can cause gastrointestinal lesions, ulcers, and elevations in plasma levels of 17-hydroxycorticosteroids and norepinephrine in monkeys (*3*). Since analogous forms of behavioral stress are thought to play an important part in the development and maintenance of human addiction to alcohol, it seemed reasonable to inquire whether avoidance conditioning would have similar effects upon the monkey's alcohol consumption.

The subjects were two 6-lb rhesus monkeys (male and female) maintained in restraining chairs (*4*). Crackers and water were available to the animals for 1 hour each day.

The first, or "preavoidance," phase of the experiment lasted 43 days, during which time base-line measurements of alcohol and water intake were made. During each 23-hour period between feedings one of three conditions was in effect: (i) an alcohol bottle alone was present (20-percent solution of 95-percent grain alcohol in water); or (ii) a water bottle alone was present; or (iii) both an alcohol and a water bottle were present. The order of presentation of conditions on successive days was as follows: alcohol, alcohol-and-water, alcohol, water, alcohol, alcohol-and-water, water.

In the second, or "avoidance," phase, which lasted 54 days, the animals were trained to press a lever to avoid electric shocks. The response-shock and shock-shock intervals were gradually decreased over a period of approximately 2 weeks to final values of 1 second each. That is, the monkey was shocked once each second as long as it failed to press the lever, but every time it pressed the lever it postponed the electric shock for 1 second. If the animal pressed the lever more frequently than once each second

Table 1. Mean alcohol and water intake. Preav., the last 3 preavoidance weeks; Av., the last 3 avoidance weeks; Postav. I, the first 3 postavoidance weeks; and Postav. II, the last 3 postavoidance weeks. The following *t*-test comparisons were significant at the .05 level or beyond. Monkey No. 1: *a* compared with *b* or *c*, *d* with *b* or *c*, *a* with *d*; *e* with *f*, *g* or *h*; *i* with *j*, *j* with *l*, *m* with *n*, *o*, or *p*. Monkey No. 2: *a* compared with *b* or *c*, *d* with *b* or *c*; *i* with *j* or *k*, *l* with *j* or *k*.

Monkey No.	Intake (ml/23 hr)			
	Preav.	Av.	Postav. I	Postav. II
	Alcohol intake: only alcohol available			
M1	48.0 (*a*)	113.8 (*b*)	113.7 (*c*)	80.1 (*d*)
M2	53.9 (*a*)	85.6 (*b*)	70.6 (*c*)	57.2 (*d*)
	Water intake: only water available			
M1	295.9 (*e*)	115.2 (*f*)	114.0 (*g*)	119.8 (*h*)
M2	232.9 (*e*)	237.5 (*f*)	233.8 (*g*)	253.3 (*h*)
	Alcohol intake: alcohol and water available			
M1	27.5 (*i*)	49.8 (*j*)	39.2 (*k*)	22.4 (*l*)
M2	33.3 (*i*)	76.4 (*j*)	70.6 (*k*)	40.6 (*l*)
	Water intake: alcohol and water available			
M1	295.0 (*m*)	90.8 (*n*)	75.8 (*o*)	85.2 (*p*)
M2	212.5 (*m*)	208.6 (*n*)	217.7 (*o*)	204.3 (*p*)

it would never be shocked. After the daily feeding, 1 hour of avoidance training was alternated with 1 hour of rest for a total of 20 hours (10 hours of avoidance training plus 10 hours of rest). An uninterrupted 3-hour rest period followed the last avoidance session of the day. A red, flashing light in front of the animal was on during avoidance sessions and off during rest sessions. The same daily sequence of water, alcohol, and alcohol-water conditions was followed as during the preavoidance phase.

In the final, "postavoidance," phase, which lasted 56 days, the avoidance schedule was no longer in effect and the red, flashing light was never turned on.

Each animal's alcohol and water intake was recorded daily. Table 1 shows the mean alcohol and water intake, in milliliters per 23 hours, during (i) the last 3 preavoidance weeks; (ii) the last 3 avoidance weeks; (iii) the first 3 postavoidance weeks; and (iv) the last 3 postavoidance weeks. Transitions from one intake level to the next were gradual.

When alcohol solution alone was available (except for crackers and water during the feeding period), both animals drank considerably more alcohol per day when they had to press the lever to avoid shocks than during the preavoidance phase. Their alcohol intake remained at a high level for the first 3 postavoidance weeks. By the beginning of the last 3 postavoidance weeks monkey No. 2 had returned to its preavoidance level of alcohol consumption, whereas monkey No. 1 did not return completely to its initial level.

Two factors argue against the possibility that the elevation in alcohol intake during the avoidance phase reflected an increased caloric demand caused by the large amount of work performed by the animals to avoid shocks: (i) alcohol intake remained high during the first 3 postavoidance weeks, even though the monkeys rarely pressed the lever; and (ii) the amount of solid food eaten by the animals each day did not change during the avoidance phase.

When water was the only fluid available to the monkeys, monkey No. 2 did not change its water intake in any consistent fashion throughout the experiment. During the avoidance phase monkey No. 1 showed a surprising drop in water intake, which persisted through the postavoidance phase. Neither animal changed its water intake during the 1-hour feeding periods. Since water consumption either remained the same or decreased during the avoidance phase, the increase in alcohol consumption does not reflect a general elevation in fluid intake by the monkeys.

Even when both fluids were available to the monkeys, their alcohol consumption increased during the avoidance phase. It remained high throughout the first 3 postavoidance weeks but returned to approximately the preavoidance base line by the beginning of the final 3 postavoidance weeks. During the avoidance phase, animal No. 1 again drank less water than before, and it continued to do so thereafter. However, animal No. 2 showed no consistent changes in water intake.

Drinkometer records showed striking differences between the animals' preavoidance- and avoidance-phase drinking patterns. On an alcohol-only or an alcohol-and-water regimen the monkeys, before avoidance conditioning, drank alcohol at a fairly uniform rate throughout the day, but during the avoidance phase and the first 3 postavoidance weeks, they drank the major portion of their daily alcohol within the first 2 or 3 hours. Also, on an alcohol-and-water regimen the animals invariably drank 20 to 30 milliliters of water before taking any alcohol during the preavoidance phase, but during the avoidance phase they consumed large amounts of alcohol before drinking any water. Paralleling their return to the base-line levels, the subjects also returned to their preavoidance-phase drinking patterns by the beginning of the last 3 postavoidance weeks.

The appearance of the animals on both the alcohol-only and the alcohol-and-water regimens during the avoidance phase indicates that they became intoxicated within the first few hours after feeding. They seemed heavy-lidded and lethargic, failed to display the aggressive responses typical of rhesus monkeys, and were easily petted and handled. They were quite normal throughout the preavoidance period and during the avoidance phase of the water-only regimen. The monkeys displayed no appreciable changes in their rate or pattern of lever pressing on days when alcohol was available, although they did receive slightly fewer shocks on days when they had only water.

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3 March 1960

An All-round Soil Percolator

Abstract. A description is given of a soil percolator which has been used both for instructional purposes and for microbiological research and has been found accurate and easy to operate. It could be used for aerobic and anaerobic experiments with a soil under water-saturated conditions.

For a diversity of studies within the field of soil microbiology the percolation technique has proved useful. In principle the technique consists in letting a solution of known composition filter through a soil column held in a tube of glass or other material and, by analysis of the percolated solution, describing the biological or nonbiological transformation it has undergone when in contact with the soil. Lees (*1*) introduced an automatic soil percolator, which was later modified (*2*), and Audus (*3*) described an apparatus which could be used for the measurement of soil-produced CO_2. More recently, Greenwood and Lees (*4*) obtained good results with a rocking respirometer, based on the percolation principle, which makes possible the measurement of both gas-exchange and reaction products from a soil sample. Theories on the percolation technique have been discussed by Lees (*2*).

Although the percolation technique might be a valuable tool in soil microbiology, percolation studies have not become very popular. This may be due mainly to the fact that percolation apparatus are not available commercially, and that the construction of one of the percolators described in the literature seems somewhat complicated.

A rather simple and inexpensive soil percolator which has proved useful and adequately accurate for nitrification and decomposition experiments is described below. The apparatus has also been used in laboratory exercises in microbiology at the University of Gothenburg for some years and has been found convenient and instructive as a means of demonstrating the microbiological processes in soil.

A mounted percolator is shown in Fig. 1. It consists of two identical round-bottomed Pyrex glass tubes *A* and *B* with a side outlet near the open end and a bottom outlet. Tube *B* is closed with a bored rubber stopper and connected with *A* by a glass tube and rubber tubing. The passage through this connection is controlled by a screw clip *C*. The second connection between *A* and *B* is through the three-way stopcock *D* and a long capillary glass tube *E* (bore 0.75 to 1.0 mm), all parts being assembled with not-too-heavy vacuum rubber tubings. Air pressure or suction is applied through the side outlet in *B*. The dimensions of the ap-

bottom. The most convenient particle size has been found to be 1 to 2 mm. The amount of soil used in one percolator varies with the properties of the soil. With "garden soil," 50 gm is practical for the standard percolator, but with sandy soils, more, and with soils rich in humus, less than this quantity should be used. The quantity of solution varies with the amount of soil and the water-holding capacity of the soil used.

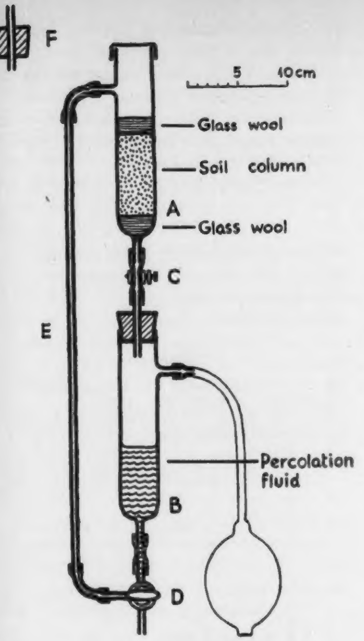

Fig. 1. Soil percolator.

paratus can be chosen to fit any purpose. However, the size of the standard percolator (Fig. 1) has proved practical for most purposes.

The soil collected for investigation should be dried in air, sieved, and mixed well before use. Fresh and untreated soil is not sufficiently homogeneous to allow several percolators to be used simultaneously, since the physical conditions of the soil vary too much from percolator to percolator. Also, with untreated soil the water flow through the columns is rendered difficult because of the packing of small particles at the bottom.

The soil is placed in tube *A* between two glass wool plugs and allowed to settle; settling is hastened by gently tapping the glass wall of the tube with the finger. In order to exclude light from the soil the tube should be partially covered with a piece of aluminum foil or heavy white drawing paper.

Initially, the percolation solution is poured in at the top of the soil column, and the flow rate is adjusted with clip *C*. Subsequent percolations are carried out by closing *C* and turning stopcock *D* so that the fluid will pass through tube *E* back to *A* when air pressure is applied. The soil is effectively aerated if *C* is again opened and air is blown through. Vigorous aeration is to be avoided, since this might lift the soil column. If aeration by pressure is made difficult because of packing of the soil, suction should be used. Surplus free water around the soil particles can also be removed by suction or, eventually, by applying pressure from above the soil column through a bored rubber stopper, *F*. If the same percolation fluid is to be used throughout an experiment of long duration, and especially if the fluid contains added organic matter, it should be removed after each percolation and refrigerated.

The percolator can be used for several types of investigation, including adsorption experiments, biological transformation of organic and inorganic compounds, enrichment of desired physiological groups of microorganisms followed by isolation in pure culture, and so on. Results of two representative percolation experiments are presented in Fig. 2. The percolator was developed for studies of the soil in a water-saturated state under aerobic conditions, but air could be replaced by any other gas in a closed system for anaerobic experiments. Further, the whole percolator could be autoclaved for experiments with sterile soil. For such use, cotton plugs should be supplied for all free outlets.

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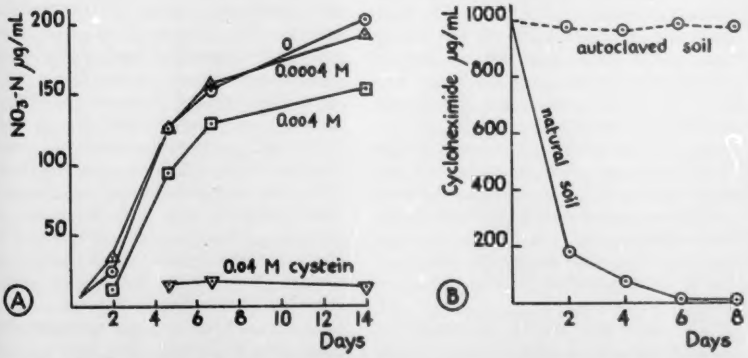

Fig. 2. (*A*) Effect of *l*-cystein on nitrification in a compost soil, *p*H 7.1. The percolation fluids were made up from 0.02*M* ammonium sulfate. (*B*) Decomposition of cycloheximide (actidione) in soil from spruce forest, *p*H 4.2. Prior to the experiment the soil had been percolated with cycloheximide solutions (100 µg/ml) during 8 weeks. Finally, two cycloheximide-decomposing bacteria and one fungus were isolated from the percolator soil.

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31 March 1960

Some Steroid Hormone-like Effects of Menthol

Abstract. Menthol or menthone, or both, like progesterone, have been shown to have the following biological activities: (i) an inhibitory action on liver and kidney aldehyde dehydrogenase activity which, under certain circumstances, is reflected in an increased rate of oxidation of D-galactose, and (ii) a stimulatory effect on the oxidation of D-galactose by two prepubertal congenitally galactosemic subjects.

We have reported on some biochemical effects produced by progesterone and androgens, both in vitro and in vivo (*1–4*). It has been possible to demonstrate that a different type of molecule—namely, DL-menthol or DL-menthone, or both—can simulate these effects of the steroids (*5*). This report presents a comparison of a number of parameters of progesterone and menthol activity.

It has been shown that the rate-determining reaction in the conversion of galactose-1-C^{14} to $C^{14}O_2$ by the soluble fraction of rabbit liver homogenate is the epimerization of uridine diphosphogalactose (UDPGal) to uridine diphosphoglucose (UDPG) (*2*). This reaction requires a catalytic amount of diphosphopyridine nucleotide (DPN) and is strongly inhibited by reduced diphosphopyridine nucleotide (DPNH) (*6*). Therefore, any agent which increases the level of DPNH would be expected to decrease the rate of galactose oxidation, whereas a decrease in the level of DPNH might be expected to accelerate galactose oxidation (*7*). This has been

demonstrated experimentally (*3*). Thus, the oxidation of galactose by the soluble fraction of kidney, a tissue known to be low in alcohol dehydrogenase (*8*), is not inhibited by alcohol but is inhibited by the addition of glycolaldehyde or an aldehyde-generating system such as propylene glycol and horse liver alcohol dehydrogenase. Progesterone ($10^{-4}M$) largely overcomes this inhibition, presumably by inhibiting DPNH formation via the aldehyde dehydrogenase reaction (*3*). Menthol ($10^{-3}M$), under comparable conditions, completely overcomes this inhibition of galactose oxidation. Moreover, menthol is oxidized by horse liver alcohol dehydrogenase in the presence of DPN, presumably to menthone. DL-Menthone also markedly inhibits the oxidation of acetaldehyde, glycolaldehyde, glyceraldehyde and propionaldehyde by aldehyde dehydrogenase activity present in the fraction obtained between 40- to 60-percent saturation of rabbit liver and kidney supernatant with ammonium sulfate. The concentration of menthone giving 50-percent inhibition is $6 \times 10^{-3}M$. No inhibition on horse liver alcohol dehydrogenase is exerted by progesterone (*3*), menthol, or menthone.

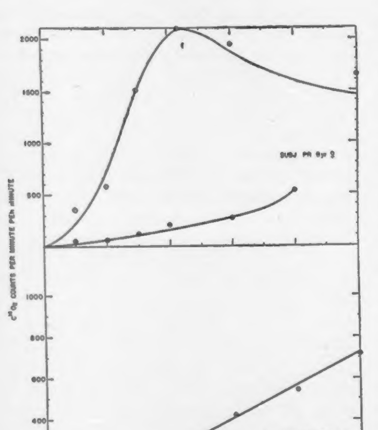

Fig. 1. Excretion of $C^{14}O_2$ by two prepubertal galactosemic subjects after intravenous administration of galactose-1-C^{14}. Subject P.R. was an 8-year-old female; L.W.J. was a 12.5-year-old male. Each child received 2 μc of galactose-1-C^{14} (4.70 μc/mg) just prior to the collection of expired carbon dioxide. Menthol (13 mg/kg), as a 25-percent solution in peanut oil, was given orally in three equal doses at 12-hour intervals during the 36 hours preceding administration of labeled galactose. The technique for collection and assay of $C^{14}O_2$ has been described (*4*). Solid circles, excretion of $C^{14}O_2$ prior to administration of menthol; open circles, excretion after administration of menthol.

Evidence of a more direct nature relating the rate of galactose oxidation to the rate of the UDPGal-4-epimerase reaction as controlled by the DPNH level has been presented elsewhere (*2*). Thus, the oxidation of UDPGal-1-C^{14} by the soluble fraction of rabbit liver was accelerated by progesterone when propylene glycol, a good substrate for alcohol dehydrogenase, was present. However, under identical conditions, the rate of oxidation of UDPG-1-C^{14} was not affected by progesterone. Presumably the hormone inhibited the oxidation of lactic aldehyde which was generated from propylene glycol (*9*). Menthol ($8.7 \times 10^{-5}M$), under comparable conditions, also stimulated the oxidation of UDPGal-1-C^{14} (by 65 percent) as compared to a propylene glycol control but had no effect on the metabolism of UDPG-1-C^{14}.

The in vitro effects described above can be summarized as follows. Galactose oxidation is inhibited in tissue preparations which are metabolizing certain aldehydic substrates. Progesterone and menthone inhibit liver and kidney aldehyde dehydrogenase activity, thereby decreasing the amount of DPNH generated by this reaction. The rate of galactose metabolism reflects this phenomenon—that is, a decrease in DPNH level permits the UDPGal-4-epimerase reaction to proceed at a rate comparable to that which obtains in the absence of aldehydic substrates.

Since menthol seemed to simulate some progesterone effects in vitro, it was of interest to determine whether the similarity extended to the galactosemic state. It can be seen from Fig. 1 that this is indeed the case. The calculations for cumulative excretions indicated that subject P. R. converted 2 percent of the administered galactose-1-C^{14} to $C^{14}O_2$ in 6 hours in the control experiment but was able to metabolize 17 percent to $C^{14}O_2$ during a comparable period after treatment with menthol. Subject L. W. J. produced essentially no $C^{14}O_2$ during the control study, but about 6 percent of the injected galactose-1-C^{14} was oxidized to $C^{14}O_2$ after menthol administration. It is of interest to note that the same subject oxidized 7 percent of the labeled sugar after progesterone administration (*4*). Normal adult subjects in similar studies oxidized 35 percent of the galactose-1-C^{14} in the control experiment but showed no increased capacity to metabolize galactose after ingestion of menthol.

The metabolic block in congenital galactosemia is at the level of P-Gal transuridylase (*10*), the enzyme which catalyzes the formation of UDP-Gal from galactose-1-phosphate. The in vitro effect of progesterone and menthol is at an enzymatic locus one step beyond the transferase level. It is not yet known whether or not the mechanism of the in vivo effect is the same as that which has been shown to operate in vitro. Further clinical trials will be necessary to determine whether these agents have any therapeutic value in congenital galactosemia.

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29 April 1960

Lethal Effect of Visible Light on Cavernicolous Ostracods

Abstract. Light intensities of the order of 1/20th that of normal sunlight are sufficient to kill ostracods from two different caves. Loss of physiological protection against light has probably occurred through the same mechanism which has resulted in the much better known loss of morphological characters in cave animals.

Loss of characters such as eyes and integumentary pigment is common in animals which have become adapted, in the evolutionary sense, to the lightless environment of caves (*1–3*). Cave animals also frequently lose physiological characters such as the ability to withstand temperature fluctuations characteristic of surface waters (*3*). In addition, they generally become more tolerant to conditions of semistarvation and may become more euryphagous. Some animals are also reported, by Absolon (*4*), to lose physiological characteristics which enable them to survive irradiation by visible light. Absolon states that a few minutes of sunlight is lethal to some cave-dwelling mites and springtails. His report, however, does not discriminate between the effects of light and of light-induced heat.

Ostracods (*Candona* sp., a new species described by Charles D. Wise) have been collected in Valdina Farm

Cave (16 mi north of D'Hanis, Medina County, Tex.) and in Cave X (about 12 mi south of Austin, Travis County, Tex.) and have been successfully cultured at 24°C ± 2° in constant darkness. They were fed dried yeast and small pieces of lettuce and celery. These animals grow and reproduce vigorously under these conditions. Young ostracods from a Valdina Farm culture were randomly divided among four bottles. Two of these bottles, containing a total of 89 animals, were placed about 2 ft from a north-facing window, in an opaque black box; the other two, containing a total of 101 animals, were placed next to the box, where they received the light coming through the window. Within 9 days all the animals which had been in the light were dead, while only 2 of the 89 controls had died.

Apparatus was then constructed so that animals could be exposed to known and constant light conditions. This apparatus consisted of cardboard boxes, with black interiors, which were 12 by 8 by 102 cm and which had a 7.6 cm square opening in one end. These boxes were so arranged that their open ends directly faced a 100-watt light bulb which was immersed in a beaker through which water constantly flowed. The light was thus filtered by 3 cm of water which removed almost all of the infrared (*5*) before it reached the animals.

Seven animals were placed in each of 13 containers with optically flat sides; these containers were oriented within the boxes so that the flat sides were perpendicular to the light. Animals from Valdina Farm Cave were put in some of the containers and animals from Cave X were put in the remainder. Placement of each animal among containers for animals from a given cave was randomly determined except for the last few from each cave. The containers were placed at various distances from the light so as to produce the exposure intensities indicated in Fig. 1. These intensities were considerably less than the intensity of direct sunlight (about 10,000 ft-ca). The control animals, cultured in continuous darkness, were kept in a completely closed box similar in size, shape, and orientation to the boxes described above. The temperature in the boxes that were open at one end would have been about 2°C higher at the end near the light than at the far end if the far end of the box had not been heated slightly. This was accomplished with appropriately adjusted gooseneck lamps.

The results, summarized in Fig. 1, show that a light intensity of approximately 1/20th that of direct sunlight is lethal to these cave-dwelling ostracods. They also show that an intensity of 10 ft-ca does not kill these animals. Furthermore, in one container, in which light intensity was 10 ft-ca, at least four young were produced after 60 days of exposure and three more were produced about 13 days later.

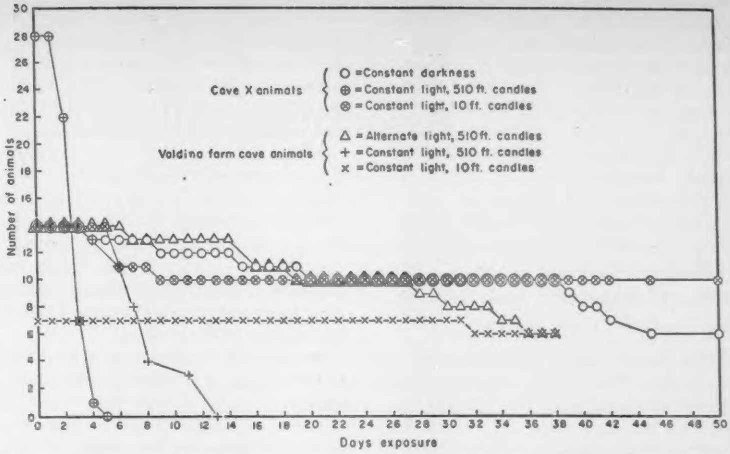

Fig. 1 Number of animals alive as a function of duration of exposure to experimental conditions.

Sensitivity to light was greater in small animals than in larger ones, and the order of death of animals within a given container was correlated with the order of size of the animals. This differential sensitivity may be responsible for most of the difference in the exposure required to kill animals from the two caves, since the average size of the Cave X animals was 0.28 mm and that of the Valdina Farm Cave animals was 0.44 mm.

One light and one dark period per day were used during the first 5 days of the alternating light and dark phase of the experiment. After this, the alternating periods were very close to 24 hours each. During the first days the dark periods were considerably longer than the light periods, and it was not until the 31st day of the experiment that the animals exposed to alternating light had accumulated a number of light-exposure hours (312) equal to the number of hours of exposure that resulted in the death of all animals exposed to constant light. At this time, 8 of the original 14 animals exposed to alternating light were still alive. There are three plausible explanations (which are not mutually exclusive) for their survival. (i) At least partial recovery from light-induced damage occurs during the dark periods. (ii) At least partial adaptation to light occurs, and with alternate dark periods there is more time for this adaptation to proceed after it is initiated. (iii) The extension of exposure over a longer period permits the animals to become older and larger, with increased resistance to the effects of light.

Sensitivity to light as is shown by the ostracods, and which I have found also, though in lesser degree, in cave-dwelling copepods (*Paracyclops fimbriatus*), is not universal in cavernicolous animals (*1, 6*).

The loss in cave animals of physiological characteristics that are adaptive to the epigeal environment is probably brought about by the same mechanism that is responsible for the much better known loss of morphological characters in these animals. The mechanism is evidently one in which mutations which are destructive of the developmental sequences leading to pigment formation, eye formation, physiological protection from light, and so on, accumulate and persist in cave populations, primarily because there is no natural selection against animals carrying them (*7*).

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7. This work was supported in part by the Research Institute of the University of Texas.

28 March 1960

Association Affairs

Additional Program Notes, Hotel Headquarters, and Housing for the New York Meeting

The preliminary announcement of the eighth New York meeting of the American Association for the Advancement of Science, to be held 26–31 December 1960 [*Science* **131**, 1616 (27 May 1960)], was principally an outline of the many sessions of the 18 AAAS sections and of some 85 participating organizations. It was apparent not only that this year's meeting in New York's Grand Central zone will be well balanced in its coverage—with every principal field of science, from astronomy to zoology, well represented—but that the programs, including the special sessions, will be particularly attractive. Since virtually all the sessions will be held in one or another of four hotels located within a few blocks of each other, the meeting also will be particularly convenient.

Additional details of the program of this 127th AAAS meeting have come in since publication of the preliminary announcement. In several instances symposia have been expanded, speakers of prominence have accepted invitations, and program chairmen have raised their original attendance estimates. The following supplementary information about various programs can be announced at this time.

Special Sessions

26 December, evening. AAAS General Symposium, "Moving Frontiers of Science," part I. Following Edward Anders, who will speak on "Recent work on meterorites," the second speaker will be H. W. Magoun, chairman of the department of anatomy, University of California, Los Angeles. He will lecture on "Development of present concepts of the organization of the brain."

27 December, evening. As previously announced, Sir Charles P. Snow will state the major aspects of the critical challenge to scientists of the conditions —social, political, and moral—that exist in the world today. Two speakers who will give their views on how scientists should respond to the current challenge will be Theodore M. Hesburgh, president of the University of Notre Dame, and William O. Baker, vice president of research, Bell Telephone Laboratories. Warren Weaver, vice president of the Alfred P. Sloan Foundation, will preside.

28 December, afternoon. AAAS General Symposium, "Moving Frontiers of Science," part II. As previously announced, George Wald, professor of biology of Harvard University, will lecture on "The molecular basis of vision." The other speaker will be Herman H. Goldstine, resident manager, Lamb Estate Research Center, IBM Corporation, Yorktown Heights, N.Y. His subject will be the current status of information theory and its mathematical basis.

29 December, evening. The annual joint address of the Society of the Sigma Xi and the United Chapters of Phi Beta Kappa will be given by Polykarp Kusch, executive officer, department of physics, Columbia University, and recipient of the Nobel prize in physics, 1955.

Symposia Notes

Physical sciences. The two-session symposium on "The Impact of the Space Program on the Sciences," to be held under the auspices of the Planetary Sciences Committee of the American Geophysical Union, is being arranged by Robert Jastrow of the National Aeronautics and Space Administration. It is scheduled for the morning and afternoon of 26 December, so that it will precede, and not conflict with, the four sessions of the American Astronautical Society (27 and 28 December) and the national meeting of the American Astronomical Society (29–31 December). Included will be papers on the structures of the planets, the atmospheres of the planets, earth-sun relationships, some frontiers of astronomy, cosmology, molecular biology, and the origin of life. Speakers of prominence have been invited, both for their scientific accomplishments and their speaking ability.

The symposia and the sessions for contributed papers of Section C–Chemistry are being arranged with the assistance of the New York Section of the American Chemical Society.

Geology and geography. Section E will sponsor a symposium on the Moho project to drill a deep hole to the outer layer of the earth's crust. This will present the latest developments in a project which was first publicly discussed at the meeting of the American Association of Petroleum Geologists in Atlantic City this spring. It will include discussion of the history of the project, its scientific objectives, instrumentation problems, and the development of special equipment for drilling in great depths of water. Harry S. Ladd of the U.S. Geological Survey will be chairman.

The program of the Association of American Geographers, New York-New Jersey Division, in addition to the symposium on "Urban Renewal," which the organization is cosponsoring, and two sessions for contributed papers, will include symposia on "Recent Post-glacial Events in Southern South America," "Africa South of the Sahara," and "Soviet Geography."

Biological sciences. The New York Academy of Sciences is scheduling a two-session conference on electrobiology with the AAAS, for 30 December. Dominic Purpura, associate professor of neurophysiology in research, College of Physicians and Surgeons, Columbia University, is chairman of the conference.

An addition to the substantial group of biological societies participating in the AAAS meeting is the Mycological Society of America, which will sponsor a special program in its field.

Psychology. Many of the details of the program of Section I are now available. Speakers and titles in the symposium on "The Physiology of Feeding and Drinking Behavior" (arranger and chairman, Eliot Stellar, University of Pennsylvania Medical School), to be held the morning of 29 December, are as follows: John Brobeck (University of Pennsylvania Medical School), "Feeding and energy balance"; Alan N. Epstein (University of Pennsylvania Medical School), "Intrahypothalamic injections and feeding and drinking"; Charles Hamilton (Veterans Administration Hospital, Philadelphia), "Hypothalamic obesity and dominance in the rhesus monkey"; Albert Stunkard (University of Pennsylvania Medical School), "Analysis of obesity in man"; Philip Teitelbaum (University of Pennsylvania Medical School), "Aphagia versus adipsia in lateral hypothalamic starvation."

The vice-presidential address of Clifford T. Morgan, University of Wisconsin, "The Neural Encoding of Sensory Information," will precede the symposium on "Concept Formation" (Roger Shepard, Bell Telephone Laboratories, arranger), also to be held the afternoon of 29 December.

Speakers and titles in the symposium on "Applications of Behavior Technology" (arranger and chairman, Murray Sidman, Walter Reed Army Institute of Research), to be held the morning

of 30 December, are: Robert Clark (Walter Reed Army Institute of Research), "Behavioral problems in radiation research"; James G. Holland (Harvard University), "Education as a problem in behavioral manipulation"; Arthur J. Bachrach (University of Virginia School of Medicine), "The social manipulation of verbal behavior"; Charles B. Ferster (Indiana University Medical Center), "Behavior deviations in children"; Thom Verhave (Eli Lilly and Company), "The use of behavior and of behavioral variables in industry"; Joseph V. Brady (Walter Reed Army Institute of Research), discussant.

Section I will cosponsor the symposium of the American Psychiatric Association, "Expression of the Emotions in Man," which has added a fifth session, to be held the evening of 30 December.

Medical sciences. The program of Section N–Medical Sciences, on "Biophysics of Physiological and Pharmacological Actions," arranged by A. M. Shanes, National Institutes of Health, to be held 26–28 December, has also been expanded from four to five sessions. Speakers and chairmen are as follows.

Part I: "Introduction and elementary systems" (transport models and models for drug interaction). A. M. Shanes (National Institutes of Health), J. F. Hoffman (National Institutes of Health), R. L. Post (Vanderbilt University School of Medicine), T. Hoshiko (Western Reserve University School of Medicine), N. L. Gershfeld (National Institutes of Health). T. Shedlovsky (Rockefeller Institute), presiding.

Part II: "Nerve—structure, electrochemistry, energetics." J. David Robertson (McLean Hospital, Boston, Mass.), W. P. Hurlbut (Rockefeller Institute), F. A. Dodge (National Institutes of Health); K. Koketsu (University of Illinois College of Medicine, Chicago), J. M. Ritchie (Albert Einstein College of Medicine). K. S. Cole (National Institutes of Health), presiding.

Part III: "Muscle, I—electrochemistry, action potentials, excitation." P. Horowicz (Washington University, St. Louis), R. Swan (Cornell University Medical School, New York), Walter H. Freygang, Jr. (National Institutes of Health), G. Falk (University of Washington), C. P. Bianchi (Institute for Muscle Disease, New York), A. M. Shanes (National Institutes of Health), William G. van der Kloot (New York University School of Medicine). A. Sandow (Institute for Muscle Disease, New York), presiding.

Part IV will be preceded by the vice-presidential address of Carl F. Schmidt, University of Pennsylvania School of Medicine, and by the presentation of the 16th Theobald Smith Award.

Part IV: "Muscle, II—structure and contraction, general energetics, possible contraction models." L. D. Peachey (Columbia University), A. Sandow (Institute for Muscle Disease, New York), R. E. Davies (University of Pennsylvania School of Medicine), R. Podolsky (Naval Medical Research Institute), Harry Grundfest (College of Physicians and Surgeons, Columbia University). W. O. Fenn (University of Rochester School of Medicine and Dentistry), presiding.

Part V: "Muscle, III—heart fibers, smooth muscle." B. F. Hoffman (State University of New York School of Medicine, New York City), J. W. Woodbury (University of Washington), S. Winegrad (National Institutes of Health), W. C. Holland (University of Mississippi Medical School), W. Trautwein (Heidelberg University), L. Hurwitz (Vanderbilt University School of Medicine), L. Barr (University of Michigan Medical School). C. Ladd Prosser (University of Illinois), presiding.

Dental research. Section Nd will hold a two-session symposium on "Keratinization" (chairman, Earl O. Butcher, New York University College of Dentistry), in the morning and afternoon of 30 December. The speakers and titles are: A. Gedeon Matoltsky (Johnson Memorial Hospital, Miami, Florida), "The mechanism of keratinization"; Russell J. Barrnett (Yale University School of Medicine), "The biochemistry of keratinization"; J. A. Rhodin and Edward J. Reith (New York University School of Medicine), "Keratinization process as seen in the electron microscope"; Irvin H. Blank (Harvard Medical School), "The effect of environment on the physical characteristics of epithelium"; George Szabo (Harvard Medical School), "Keratinization in tissue culture"; Jerome P. Parnell (College of Medicine, Downstate Medical Center of New York), "Effects of vitamin A on keratinization"; M. L. Watson (University of Rochester School of Medicine and Dentistry), "Fine structure of ameloblastic fibril formation"; K. A. Piez (National Institute of Dental Research), "Chemistry of the organic matrix of enamel."

Social and economic sciences. The program of the National Academy of Economics and Political Science, cosponsored by Pi Gamma Mu National Social Science Honor Society, will be a symposium, "The Technological Revolution and its Policy Influence," to be held the morning of 27 December.

History of science. The History of Science Society, which will hold its biennial meeting with the AAAS, has announced that the first George Sarton Memorial Lecture will be given by René Dubos of the Rockefeller Institute on 27 December.

Speakers and titles in the symposium on "Fairly Recent Science and Technology" (chairman, Lynn T. White, University of California), to be held the afternoon of 27 December, are: Alexander M. Ospovat (University of North Dakota), "Abraham Gottlob Werner's ideas on science and education"; Harold I. Sharlin (Polytechnic Institute of Brooklyn), "The engineering gap between Faraday's discovery of electromagnetic induction and the electric dynamo."

Speakers and titles in the symposium "The Scientific Mainstream" (chairman, Duane H. D. Roller, University of Oklahoma), to be held the afternoon of 28 December, are: Allen G. Debus (Harvard University), "The development of analytic methods in chemistry prior to Robert Boyle"; C. Doris Hellman (Pratt Institute), "A kaleidoscope of appraisals of the importance of Tycho and Kepler"; Rudolph E. Siegel (University of Buffalo), "Galen's experiments and clinical observations on circulation and respiration."

Speakers and titles in the symposium "Reports on Work in Progress" (chairman, Marshall Clagett, University of Wisconsin), to be held the morning of 29 December, are: Saul Benison (Columbia University), "Oral history of contemporary American science"; Harold L. Burstyn (Harvard University), "Galileo's attempt to prove that the earth moves"; Gerald J. Gruman (Johns Hopkins University), "Medical alchemy: A study in comparative history"; Thomas M. Smith (University of Oklahoma), "Application of the digital computer to the analysis of variant readings of medieval texts"; W. James King (Smithsonian Institution), "The role of measurement in the natural philosophy of Galileo and Huygens"; Eri Yagi (Yale University), "The growth of modern science in Japan"; Duane H. D. Roller (University of Oklahoma), "Report on the teaching of history of science in American colleges"; Allan R. Robinson (Harvard University), "The development of atomic models: Kelvin to Bohr."

Local Committees

The Association, again this year, is fortunate in having an ideally qualified general chairman of the meeting and fortunate in the committee chairman he has already appointed.

The general chairman of the eighth New York meeting is Eger V. Murphree, president of Esso Research and Engineering Company, who has been a member of the advisory committee of the AEC since 1950, is a member of the National Academy of Sciences, and holds membership in a number of scientific societies.

The chairman of the Committee on Exhibits is William O. Baker, vice president for research, Bell Telephone Laboratories; he was a member of the same committee when the AAAS met in New York in 1956.

The chairman of the Committee on Public Information is Marion Harper, Jr., president of McCann-Erickson, Inc.; he headed the same committee at the previous New York meeting.

The chairman of the Committee on Physical Arrangements is Harry A. Charipper, head of the department of biology, New York University, Washington Square Center, who aided that committee in 1949 and 1956; he is also in charge of local arrangements for this year's meeting of the American Society of Zoologists.

Housing

Four of the five hotels for the AAAS meeting have established uniform flat rates, much lower than their usual rates, for AAAS members and others attending the meeting. Thus, everyone who makes room reservations through the AAAS Housing Bureau can be assured of substantial savings.

Beginning with this issue, the advertising pages of *Science* will carry, at frequent intervals, announcements of hotel accommodations and rates, together with a coupon which should be filled out and sent, *not* to any hotel directly, but to the AAAS Housing Bureau in New York. All applications for hotel rooms will be filled in the order of receipt. Those who apply early are assured of accommodations in the hotel of their first choice. Expenses can be reduced still further if two people share a room or if three or more people share a suite. Upon request, all hotels will place comfortable rollaway beds in rooms or suites at $3 per night.

Registration

Both the technical, or program, sessions and the special sessions are open to all interested persons. Although registration for these sessions is not mandatory, it is expected that all who attend will wish to pay the AAAS registration fee of $3 and thus contribute their proportionate share to the heavy expenses of the meeting. (The registration fee for the husband or wife of a registrant, if a second General Program is not required, is $1.)

Each registrant receives the General Program, convention literature, a listing in the Visible Directory of Registrants, and a Convention Badge; the latter assures him all privileges of the meeting, discounts on tickets of admission to tourist attractions, and the like. The badge *is* required for admission to the large-scale exhibits, the AAAS Science Theatre, the presidential reception, and the AAAS Smoker. Re-

freshments will be served at the last two events.

Advance registration ($3.50, since prepaid postage is included) has some decided advantages: Delay at the registration desks upon arrival is eliminated; since the General Program is sent out by first-class mail early in December, the advance registrant can determine at his leisure which events and sessions he particularly wishes to attend; and the registrant's name is posted in the Visible Directory of Registrants as the meeting opens (the hotel room may be added later, by the registrant himself).

An announcement on advance registration, with a coupon, will also be found in the advertising pages of this issue and at intervals hereafter.

AAAS Headquarters

As stated in the Preliminary Announcement, for the AAAS as a whole, there will be coheadquarters hotels. The Commodore, with its large ballroom, will accommodate the evening events, general sessions, the AAAS business sessions, and the AAAS Pressroom. The Biltmore will house the AAAS Office, the Visible Directory of Registrants, the Annual Exposition of Science and Industry, and the AAAS Science Theatre. Each of the two hotels—located one and a half blocks apart, on two sides of Grand Central Station (they can be reached by underground passages *through* the station)—will have AAAS Main Registration–Information Center facilities.

The Commodore will also accommodate the American Society of Zoologists and Section N; the Biltmore will house the other biological and medical groups and some of the physical sciences as well. The Roosevelt will be headquarters for the American Astronomical Society, for the science teaching societies, and for the social and economic sciences. The Belmont Plaza is the headquarters hotel for geology and geography, Section H, the History of Science Society, and other organizations of the "L" series. At present, no sessions are scheduled in the Waldorf-Astoria, 49th Street and Park Avenue, but 400 of its sleeping rooms are available, at minimum rates.

A detailed list of the headquarters for each section and participating organization is given below, since it is an obvious convenience for each person attending the meeting to have this information before he applies for room reservations.

Other Hotel Headquarters

AAAS sections are listed alphabetically and societies are listed in the same sequence, by discipline.

Commodore (2000 rooms), 42nd Street and Lexington Avenue.

AAAS (Board of Directors, Coun-

cil); General Events and Special Sessions; Pressroom.

AAAS Committee on Science and the Promotion of Human Welfare; AAAS Sections F–Zoological Sciences, N–Medical Sciences, and P–Industrial Science.

American Geological Institute, National Geographic Society.

American Society of Zoologists.

Federation of American Societies for Experimental Biology.

Academy Conference, American Council on Women in Science, Conference on Scientific Communication, National Association of Science Writers, National Science Foundation, New York Academy of Sciences, Scientific Research Society of America, Sigma Delta Epsilon, Society of the Sigma Xi, United Chapters of Phi Beta Kappa.

Biltmore (1000 Rooms), 43rd Street and Vanderbilt Avenue.

AAAS Office; Annual Exposition of Science and Industry; AAAS Science Theatre; Visible Directory of Registrants.

AAAS Sections A–Mathematics, B–Physics, G–Botanical Sciences, I–Psychology, Nd–Dentistry, and O–Agriculture.

American Mathematical Society, Association for Computing Machinery, Society for Industrial and Applied Mathematics.

American Astronautical Society, American Institute of Physics, American Meteorological Society, Sigma Pi Sigma.

American Association of Clinical Chemists.

Society of Systematic Zoology.

American Institute of Biological Sciences, American Society of Naturalists, Beta Beta Beta Biological Society, Ecological Society of America, Mountain Lake Biological Station, Nature Conservancy, Society for the Study of Evolution, Society of General Physiologists.

Botanical Society of America, Mycological Society of America, Torrey Botanical Club.

Alpha Epsilon Delta, American Physiological Society, American Psychiatric Association.

American College of Dentists; American Dental Association; International Association for Dental Research, North American Division.

Society for Industrial Microbiology.

American Geophysical Union.

Roosevelt (1100 rooms), 44th Street and Vanderbilt Avenue.

AAAS Cooperative Committee on the Teaching of Science and Mathematics.

AAAS Sections C–Chemistry, D–Astronomy, K–Social and Economic Sciences, M–Engineering, Np–Pharmacy, and Q–Education.

American Chemical Society.

American Astronomical Society, Astronomical League.

National Association of Biology Teachers.

American Economic Association, American Political Science Association, American Society of Criminology, American Sociological Association, American Statistical Association, Econometric Society, Metric Association, National Academy of Economics and Political Science, National Institute of Social and Behavioral Sciences, Pi Gamma Mu National Social Science Honor Society, Social Science Research Council.

Engineers Joint Council, Engineering Manpower Commission, Tau Beta Pi Association.

American Association of Colleges of Pharmacy; American College of Apothecaries; American Pharamaceutical Association, Scientific Section; American Society of Hospital Pharmacists; National Association of Boards of Pharmacy.

Institute of Management Sciences.

American Educational Research Association, Council for Exceptional Children, National Association for Research in Science Teaching, National Science Teachers Association, American Nature Study Society.

Conference on Scientific Manpower, National Academy of Sciences–National Research Council, Scientific Manpower Commission.

Belmont Plaza (800 rooms), 49th Street and Lexington Avenue.

AAAS Sections E–Geology and Geography, H–Anthropology, and L–History and Philosophy of Science.

Association of American Geographers, Geological Society of America, National Speleological Society.

Conference on Scientific Manuscripts, History of Science Society, Philosophy of Science Association, Society for General Systems Research, Society for the History of Technology.

RAYMOND L. TAYLOR
Associate Administrative Secretary

Forthcoming Events

August

15–23. Soil Science, 7th intern. cong., Madison, Wis. (R. Bradfield, Dept. of Agronomy, Cornell Univ., Ithaca, N.Y.)

15–24. Crystallography, intern. cong., Cambridge, England. (W. H. Taylor, Cavendish Laboratory, Cambridge, England)

15–25. Chemistry of Natural Products, IUPAC symp., Melbourne, Canberra, and Sydney, Australia. (Convener, Symposium Organizing Committee, Box 4331, G.P.O., Melbourne)

15–25. International Geological Cong., 21st session, Copenhagen, Denmark. (IGC, Mineralogical-Geological Museum, Univ. of Copenhagen, Øster Boldgade 7, Copenhagen K)

15–25. International Paleontological Union, Copenhagen, Denmark. (J. Roger, Service d'Information Geologique, B.R.G.-G.M., 74, rue de la Fédération, Paris 15e, France)

15–25. Sedimentology Cong., 6th intern., Copenhagen, Denmark. [General Secretary, IAS, c/o Institut Français du Petrole, 4, place Bir Hacheim, Rueil-Malmaison (Seine-et-Oise), France]

16–18. Biological Effects of Microwave Radiation, 4th annual conf., New York, N.Y. (M. Eisenbud, New York Univ. Post Graduate Medical School, 550 First Ave., New York 16)

16–19. Society of Automotive Engineers, San Francisco, Calif. (R. W. Crory, SAE, Meetings Operation Dept., 485 Lexington Ave., New York 17)

17–19. Hydraulics Conf., Seattle, Wash. (W. H. Wisely, American Soc. of Civil Engineers, 33 W. 39 St., New York 18)

17–19. University Nuclear Reactors, Gatlinburg, Tenn. (University Relations Div., Oak Ridge Inst. of Nuclear Studies, P.O. Box 117, Oak Ridge, Tenn.)

17–21. Ionization Phenomena in Gases, 4th intern. conf., Uppsala and Stockholm, Sweden. (A. Nilsson, Fysikum, Uppsala)

18–19. Submarine and Space Medicine, 2nd intern. symp., Stockholm, Sweden. (H. Bjurstedt, Laboratory of Aviation Medicine, Karolinska Institutet, Stockholm, 60)

20. American Inst. of Ultrasonics in Medicine, Washington, D.C. (D. M. Stillwell, Dept. of Physical Medicine and Rehabilitation, Univ. of Colorado Medical Center, Denver 20)

21–24. Latin-American Cong. of Angiology, Rio de Janeiro, Brazil. (R. C. Mayall, Caixa Postal 1822, Rio de Janeiro)

21–24. National Council of Teachers of Mathematics, Salt Lake City, Utah. (M. H. Ahrendt, 1201 16 St., NW, Washington 6)

21–25. American Soc. of Pharmacology and Experimental Therapeutics, Seattle, Wash. (H. Hodge, ASPET Dept. of Pharmacology, Univ. of Rochester, Rochester, N.Y.)

21–26. American Cong. of Physical Medicine and Rehabilitation, Washington, D.C. (Mrs. D. C. Augustin, 30 N. Michigan Ave., Chicago 2, Ill.)

21–26. Physical Medicine, 3rd intern. conf., Washington, D.C. (W. J. Zeiter, 2020 E. 93 St., Cleveland, Ohio)

21–6. Pacific Science Cong., 10th. Honolulu, Hawaii. (Secretary-General, 10th Pacific Science Cong., Bishop Museum, Honolulu 17)

22–25. American Astronomical Soc., Mexico City, Mexico. (J. A. Hynek, Smithsonian Astrophysical Observatory, 60 Garden St., Cambridge 38, Mass.)

22–25. American Physiological Soc., San Francisco, Calif. (R. G. Daggs, APS, 9650 Wisconsin Ave., NW, Washington 14)

22–26. Plasma Physics, symp., Gatlinburg, Tenn. (University Relations Div., Oak Ridge, Inst. of Nuclear Studies, P.O. Box 117, Oak Ridge, Tenn.)

22–26. Western Resources, 2nd annual conf., Boulder, Colo. (M. E. Garnsey, Dept. of Economics, Univ. of Colorado, Boulder)

23–25. Assoc. for Computing Machinery, natl., Milwaukee, Wis. (J. Moshman, ACM, Council for Economic and Industry Research, 1200 Jefferson Davis Highway, Arlington 2, Va.)

23–25. Cryogenic Engineering Conf., Boulder, Colo. (K. D. Timmerhaus, CEC, Dept. of Chemical Engineering, Univ. of Colorado, Boulder)

23–26. American Statistical Assoc., annual, Palo Alto, Calif. (D. C. Riley, ASA, Beacon Bldg., 1757 K St., NW, Washington 6)

23–26. Biological Photographic Assoc., Salt Lake City, Utah. (Miss J. H. Waters, Box 1668, Grand Central Post Office, New York 17)

23-26. Institute of Mathematical Statistics, annual, Stanford, Calif. (W. Kruskal, Dept. of Statistics, Eckhart Hall, Univ. of Chicago, Chicago 37, Ill.)

23–28. American Ornithologists' Union, Ann Arbor, Mich. (H. G. Diegnan, Division of Birds, U.S. National Museum, Washington 25)

24–27. Forest Biology Conf., Seattle, Wash. (Miss E. N. Wark, Technical Assoc. of the Pulp and Paper Industry, 360 Lexington Ave., New York 17)

24–27. Internal Medicine, 6th intern. cong., Basel, Switzerland. (Secretariat, 6th ICIM, 13 Steinentorstre, Basel)

24–2. International Union for the History and Philosophy of Science, Stanford, Calif. (R. Taton, 64, rue Gay-Lussac, Paris 5e, France)

25–27. Chemical Organization of Cells, 2nd conf., Madison, Wis. (J. F. A. McManus, Dept. of Pathology, Univ. of Alabama Medical Center, Birmingham)

25–3. High Energy Nuclear Physics, intern. conf., Rochester, N.Y. (W. A. Jamison, Dept. of Physics and Astronomy, Univ. of Rochester, Rochester 20)

27–30. International Union of Biological Sciences, section of embryology, Pallanza, Italy. (F. E. Lehmann, Kuhnweg 10, Berne, Switzerland)

28–31. American Phytopathological Soc., Green Lake, Wis. (W. B. Hewitt, Dept. of Plant Pathology, Univ. of California, Davis)

28–31. Potato Assoc. of America, Green Lake, Wis. (R. L. Sawyer, Long Island Vegetable Research Farm, Cornell Univ., Riverhead, N.Y.)

28–31. Soil Conservation Soc. of America, Guelph, Ontario, Canada. (H. W. Pritchard, 838 Fifth Ave., Des Moines 14, Iowa)

28–1. American Inst. of Biological Sciences, annual, Norman, Okla. (H. T. Cox, AIBS, 2000 P St., NW, Washington 6)

The following 20 meetings are being held in conjunction with the AIBS meeting at Stillwater, Okla.

American Bryological Soc. (G. J. Ikenberry, Dept. of Botany and Plant Pathology, Oklahoma State Univ., Norman)

American Fern Soc. (U. T. Waterfall, Dept. of Botany, Oklahoma State Univ., Norman)

American Microscopical Soc. (R. W. Jones, Dept. of Zoology, Oklahoma State Univ., Norman)

American Soc. for Horticultural Science. (D. G. White, Dept. of Horticulture, Oklahoma State Univ., Norman)

American Soc. of Limnology and Oceanography. (T. C. Dorris, Dept. of Zoology, Oklahoma State Univ., Norman)

American Soc. of Plant Physiologists. (C. L. Leinweber, Dept. of Botany and Plant Pathology, Oklahoma State Univ., Norman)

American Soc. of Plant Taxonomists. (U. T. Waterfall, Dept. of Botany, Oklahoma State Univ., Norman)

American Soc. of Zoologists. (R. W. Jones, Dept. of Zoology, Oklahoma State Univ., Norman)

Biometric Soc. (ENAR). (C. Marshall, Statistics Laboratory, Oklahoma State Univ., Norman)

Botanical Soc. of America. (W. W. Hanson, Dept. of Botany and Plant Physiology, Oklahoma State Univ., Norman)

Ecological Soc. of America. (A. Stebler, Oklahoma Cooperative Wildlife Research Unit, Oklahoma State Univ., Norman)

Genetic Soc. of America. (H. Bruneau, Dept. of Zoology, Oklahoma State Univ., Norman)

Mycological Soc. of America. (J. E. Thomas, Dept. of Botany and Plant Pathology, Oklahoma State Univ., Norman)

National Assoc. of Biology Teachers. (T. Overmire, 1709 Admiral Rd., Stillwater, Okla.)

Nature Conservancy. (A. Stebler, Oklahoma Cooperative Wildlife Research Unit, Oklahoma State Univ., Norman)

Phi Sigma Soc. (D. E. Howell, Dept. of Entomology, Oklahoma State Univ., Stillwater)

Phycological Soc. of America. (I. V. Holt, Dept. of Botany, Oklahoma State Univ., Norman)

Society for Industrial Microbiology. (R. C. Allred, Central Research Laboratory, Continental Oil Co., Ponca City, Okla.)

Society for the Study of Development and Growth. (R. W. Jones, Dept. of Zoology, Oklahoma State Univ., Norman)

Society of Protozoologists. (D. W. Twohy, Dept. of Zoology, Oklahoma State Univ., Norman)

Tomato Genetics Cooperative. (D. G. White, Dept. of Horticulture, Oklahoma State Univ., Norman)

28–1. Association of American Geographers, East Lansing, Mich. (M. F. Burrill, Office of Geography, Dept. of Interior, Washington 25)

28–1. Diseases of the Chest, intern. cong., Vienna, Austria. (M. Kornfeld, 112 E. Chestnut St., Chicago 11, Ill.)

28–2. Combustion, 8th intern. symp., Pasadena, Calif. (Office of Industrial Associates, California Inst. of Technology, Pasadena)

28–2. International Pharmaceutical Federation, Copenhagen, Denmark. (A. W. Tønnesen, Bispebjerg Hospital, Copenhagen, N.V.)

28–2. International Soc. for the Welfare of Cripples, world cong., New York, N.Y. (D. V. Wilson, 701 First Ave., New York 17)

28–3. Electron Microscopy, European regional conf., Delft, Netherlands. (A. L. Housink, Lab. v. Microbiologie, Julianalaan 67A, Delft)

28–3. Histochemistry and Cytochemistry, 1st intern. cong., Paris, France. (R. Wegmann, Institut d'Histochimie Medicale, 45, rue des Saints-Pères, Paris 6e)

29–31. American Sociological Assoc., New York, N.Y. (D. R. Young, Russell Sage Foundation, 505 Park Ave., New York)

29–31. Clinical Chemists (Canadian and American Societies), annual, Montreal, Canada. (E. Harpur, Montreal Children's Hospital, Montreal)

29–31. Electron Microscope Soc. of America, 18th annual, Milwaukee, Wis. (W. C. Bigelow, Dept. of Chemical and Metallurgical Engineering, Univ. of Michigan, Ann Arbor)

29–31. Metallurgy of Elemental and Compound Semiconductors, Boston, Mass. (E. O. Kirkendall, AIME, 29 W. 39 St., New York 18)

29–31. Water Quality Measurement and Instrumentation, PHS symp., Cincinnati, Ohio. (R. T. Hyde, Robert A. Taft Sanitary Engineering Center, 4676 Columbia Parkway, Cincinnati 26)

29–1. Ballistic Missile and Space Technology, 5th symp., Los Angeles, Calif. (C. T. Morrow, Space Technology Laboratories, P. O. Box 95001, Los Angeles 45)

29–1. Mathematic Assoc. of America, 41st summer, East Lansing, Mich. (H. M. Gehman, Univ. of Buffalo, Buffalo 14, N.Y.)

29–2. Semiconductors, 5th intern. conf., Prague, Czechoslovakia. (M. Matyas, Inst. of Technological Physics, Cukrovarnickå 10, Prague 5)

29–3. American Mathematical Soc., natl. summer, East Lansing, Mich. (Miss L.

Charron, AMS, Administrative Services, 190 Hope St., Providence, R.I.)

29–3. International Cong. on Low Temperature Physics, Toronto, Canada. (IUPAP, 3, boulevard Pasteur, Paris 15^e, France)

29–3. International Conf. on Nuclear Structure, Kingston, Ontario, Canada. (L. G. Elliott, Atomic Energy of Canada, Chalk River, Ontario, Canada)

29–16. World Forestry Conf., 5th, Seattle, Wash. (I. T. Haig, 5th WFC, Dept. of State, Washington 25)

31–6. International cong. de Sociologie, 19th, Mexico City, Mexico. (C. C. Zimmerman, 200 Emerson Hall, Harvard Univ., Cambridge 38, Mass.)

31–7. Applied Mechanics, 10th intern. cong., Stresa, Italy. (F. Rolla, Consiglio Nazionale delle Ricerche, Ufficio Relazioni Internazionali, Piazza delle Scienza 7, Rome, Italy)

31–7. British Assoc. for the Advancement of Science, annual, Cardiff, South Wales. (Secretary, BAAS, 18 Adam St., Adelphi, London, W.C.2, England)

September

1–3. Nephrology, 1st intern. cong., Geneva and Evian, Switzerland. (G. Richet, Hôpital Necker, 149 rue de Sèvres, Paris 15^e, France)

1–7. American Psychological Assoc., Chicago, Ill. (L. F. Carter, 249 Mantua Rd., Pacific Palisades, Calif.)

1–7. Nutrition, 5th intern. cong., Washington, D.C. (M. O. Lee, 9650 Wisconsin Ave., Washington 14)

2–5. Astronomical League, Haverford, Pa. (R. Dakin, 720 Pittsford-Victor Rd., Pittsford, N.Y.)

3–10. International Cong. of Preventive Medicine and Social Hygiene, 8th, Bad Aussee, Austria. (A. Rottmann, Liechtensteinstrasse 32/4, Vienna 9, Austria)

4–9. Cell Biology, 10th intern cong., Paris, France. (M. Chèvremont, Institut d'Histologie, 20, rue de Pitteurs, Liege, Belgium)

4–9. Laurentian Hormone Conf., Mont Tremblant, Quebec, Canada. (Arrangements Committee, Laurentian Hormone Conf., 222 Maple St., Shrewsbury, Mass.)

4–10. International Soc. of Orthopaedic Surgery and Traumatology, 8th cong., New York, N.Y. (A. Bailleux, Société de Chirurgie Orthopedique et de Traumatologie, 34, rue Montoyer, Brussels, Belgium)

4–10. World Cong. of Anaesthesiologists, Toronto, Canada. (R. A. Gordon, 516 Medical Arts Bldg., Toronto 5)

4–14. International Societies of Hematology and Blood Transfusion, 8th cong., Tokyo, Japan. (S. Murakami, Blood Transfusion Laboratory, Japanese Red Cross Soc., Shibuya, Tokyo)

5–7. Society for Biological Rhythm, 7th conf., Siena, Italy. (A. Sollberger, Dept. of Anatomy, Caroline Inst., Stockholm 60)

5–9. Chemical Engineering (Czechoslovak Chemical Soc.), Prague, Czechoslovakia. (Technická 1905, Prague-Dejvice, Czechoslovakia)

5–10. Microbiology of Non-Alcholic Beverages, 5th intern. symp., Evian, France. (D. A. A. Mossell, Intern. Assoc. of Microbiological Societies, c/o Central Inst. for Nutrition Research, Catherinjnesingel 61, Utrecht, Netherlands)

5–9. Medium and Small Power Reactors, conf., Vienna, Austria. (International Atomic Energy Agency, 11 Kärntner Ring, Vienna 1)

5–10. Operational Research, 2nd intern. conf., Aix-en-Provence, France. (International Federation of Operational Research Societies, 11 Park Lane, London, W.1)

5–12. International Soc. of Bioclimatology and Biometerology, 2nd cong., London, England. (E. M. Glaser, Dept. of Physiology, . London Hospital Medical College, Turner St., London, E.1)

5–15. International Scientific Radio Union, London, England. (R. L. Smith-Rose, Radio Research Station, DSIR, Ditton Park, Slough, Bucks, England)

5-17. Photogrammetry, 9th intern. cong., London, England. (J. B. P. Angwin, Intern. Soc. for Photogrammetry, 18 Cavendish Sq., London, W.1)

6–8. Nuclear and Radio-Chemistry, symp., Chalk River, Ontario, Canada. (R. H. Betts, Atomic Energy of Canada Ltd., Chalk River, Ontario)

6–17. Use of Radioactive Isotopes in the Physical Sciences and Industry, conf., Copenhagen, Denmark. (International Atomic Energy Agency, 11 Kärntner Ring, Vienna 1, Austria)

7–8. Canadian Textile Seminar, 7th, Kingston, Ontario, Canada. (J. M. Merriman, Textile Technical Federation of Canada, 223 Victoria Ave., Westmount, P.Q., Canada)

7–9. Canadian High Polymer Forum, 10th, Ste. Marguerite, near Montreal, Quebec, Canada. (D. A. I. Goring, CHPF, Pulp and Paper Research Inst., McGill Univ., Montreal)

7–9. International Soc. of Geographical Pathology, 7th conf., London, England. (J. S. Young, ISGP, c/o Dept. of Pathology, Forresterhill, Aberdeen, Scotland)

New Products

The information reported here is obtained from manufacturers and from other sources considered to be reliable. Neither Science *nor the writer assumes responsibility for the accuracy of the information. A coupon for use in mailing inquiries concerning the items listed is included in the post card insert. Circle the department number of the items in which you are interested on this coupon.*

■ RELAYS are hermetically sealed mercury types said to be capable of operation at temperatures as high as 1200°F. Sliding contacts are used to avoid contact bounce. The relays are filled with dielectric gas of high arc-quenching value. (Sorrels-Johnson Corporation, Dept. Sci627, 363 Rantoul St., Beverly, Mass.)

■ PROPORTIONING PIPETTES use a peristaltic pump to dispense equal aliquots of liquid. One model of the device permits dial selection for automatic delivery of up to 20 multiples of a fixed aliquot per operation. A second model transfers integral multiples of the aliquot until stopped by the operator when the required member appears on a counter. Nominal volume is 0.3 ml/rev. An alternative flexible tube for 0.2 ml/rev is available. Deviation of total volume delivered by a number of revolutions is said to be less than ±1 percent of the mean volume per single revolution. (Baird & Tatlock Ltd., Dept. Sci623, Chadwell Heath, Essex, England)

■ KELVIN BRIDGE measures resistance from 10 μohm to 100 ohm. Test leads more than 100 ft long may be employed with accuracy ±0.25 percent above 100 μohm and ±1 μohm below 100 μohm. Test leads of any length are available with either C-clamp or spring-clamp terminations. (Shallcross Manufacturing Co., Dept. Sci626, Selma, N.C.)

■ GAS DETECTOR is a portable instrument with probe-type detector connected by up to 100 ft of cable. Calibration is in percentage of lower explosion limit of desired gas. An adjustable meter trip provides buzzer alarm actuation. An adjustable current meter allows approximate classification of gas constituents in many gas mixtures. A battery and charger are built in and the instrument may also be operated from a 110-volt a-c source. (Houston Instrument Corp., Dept. Sci628, P.O. Box 22234, Houston 27, Tex.)

■ ADMITTANCE BRIDGE for the range 30 to 300 Mcy/sec uses a thermistor element in a servo feedback system as conductance standard. Accuracy is said to be ±2 percent over the entire frequency range. Capacitance range is ±40 pf and conductance range is 0 to 50 mmho. Voltage applied to the component under test is usually less than 50 mv. Signal sources and detectors are separately available. (Marconi Instruments, Dept. Sci625, 111 Cedar Lane, Englewood, N.J.)

■ RANDOM-SIGNAL CORRELATOR, may be used to measure the normalized cross correlation between two signals, either random or periodic. Frequency range is 2 cy to 250 kcy/sec. Input voltage range is 20 mv to 2 v r.m.s., and gain is continuously adjustable from 1 to 100 in each channel. Accuracy is said to be ±1 percent. An output selector permits selection of either of the two signal channels or of the correlated signal. After the two channels have been equalized, positive or negative correlation can be read directly on an r.m.s. voltmeter. (Flow Corp., Dept. Sci634, 85 Mystic St., Arlington, Mass.)

■ ALIPHATIC ACIDS, their methyl esters, alcohols, and amines from C_8 to C_{18} are available with purity said to be 99.5 percent as judged from vapor-phase chromatograms. Purification is effected by vacuum fractionation. (Lachet Biochemical Co., Dept. Sci640, 2202 W. 107th Pl., Chicago 43, Ill.)

■ VOLATILE MATTER DETERMINATION in coal and coke, according to ASTM method D271–48, is aided by apparatus that controls automatically the rate at which the sample crucible is lowered and the length of time it remains in the

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New Products

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furnace. Three dials allow selection from a variety of rates of descent and heating times. Two samples are accommodated by the apparatus at one time. (Laboratory Equipment Corp., Dept. Sci642, P.O. Box 151, St. Joseph, Mich.)

■ THIN SECTIONING MACHINE cuts dentive sections as thin as 35 μ and crystal sections as thin as 0.005 to 0.10 in. Sections may be cut from specimen blocks ¾ by 1½ by 3 in. in less than 5 minutes. Sections are said to be produced with finished surfaces ready for use in routine examinations without polishing. (Will Corporation, Dept. Sci 644, P.O. Box 3927, Brighton Station, Rochester 10, N.Y.)

■ ADJUSTABLE-LEAK VALVE consists of a vacuum-valve body containing a sealed stem actuated by a vernier drive. A groove machined along the axis of the stem of the valve increases in depth at a controlled rate per unit length. Effective opening ranges from 0 to 0.000024 in.^{2} and leak rate ranges to 1.8 std cm^3/sec for 25 turns of the valve. (Vactronic Lab Equipment, Inc., Dept. Sci 646, East Northport, N.Y.)

■ PULSE GENERATOR produces pulses of ½ μsec duration at repetition frequencies between 0.5 and 150 Mcy/sec. Pulses can be continuously varied over a 10-to-1 range in steps up to 50 μsec. Amplitude is 300 volts peak to peak into a 93-ohm load. The unit can be self-triggered or synchronized externally up to 30 kcy/sec. Calibrated delay ranges to 11,000 μsec are provided. (Arenberg Ultrasonic Laboratory, Inc., Dept. Sci647, 94 Green St., Jamaica Plain 30, Mass.)

■ ANALOG-TO-DIGITAL CONVERTER will directly convert the amplitude of carrier system voltages to digital codes without intermediate a-c-to-d-c conversion. The unit is reversible and as a digital-to-analog converter it converts parallel digital codes to a-c carrier voltages. The amplifier, comparator, and conversion networks will accept frequencies to 100 kcy/sec yielding accuracies said to be ±0.02 percent ±½ count. Units are available for conversion of voltage to 8-to-13 bit binary or to binary-decimal codes of 2, 3, or 4 digits resolution. (Epsco, Inc., Dept. Sci649, 275 Massachusetts Ave., Cambridge, Mass.)

■ HIGH-SPEED CAMERA SYSTEM consists of the camera, camera control unit, light control unit, and flash lamp. In the camera a rotating mirror spun by an air turbine sends the image to the rim of a circular film box. The camera control unit contains the elements necessary for operation of the Kerr-cell

electro-optical shutter. The flash lamp is a standard high luminosity electronic flash unit. Framing rate is 480 to 1.6 million pictures per second, depending on mirror speed and frame size. At the maximum rate, 960 one-quarter frame 35-mm pictures are taken in one run. Exposure time is adjustable from 0.05 μsec. to 1.0 μsec, independent of framing rate. Camera and light source are triggered by an external electrical signal. Delay between trigger and start of photography is continuously variable from 0.00004 to 0.01 sec. (Benson-Lehner Corporation, Dept. Sci645, 1860 Franklin St., Santa Monica, Calif.)

■ BLACK BODY INFRARED SOURCE is a miniature unit designed for calibrating the seeking head of infrared guided missiles and other infrared sensitive elements in the 200° to 600°C temperature range. Temperature control is provided by a separate unit which senses the temperature of the radiating core by means of a platinum resistance thermometer. The radiating element is a pure silver core with a conically shaped cavity. The surface of the cone is coated with a refractory material to increase its emissivity to near unity. (Perkin-Elmer Corp., Dept. Sci658 Norwalk, Conn.)

■ MOUSE BREEDING BOXES, made of polyethylene, can be sterilized by autoclave. A smooth finish is said to prevent capillary action, and a built-in nesting feature prevents sticking. Punched lips for drying on washer conveyer are available. (Consolidated Molded Products Corp., Dept., Sci652, 329 Cherry St. Scranton 2, Pa.)

■ DIGITAL DISPLAY UNIT can also serve as a general-purpose oscilloscope. The unit provides a 6- by 10-cm raster presentation of digital data shown as cathode-ray-beam modulation by means of bistable intensity circuits. Positive-going pulses of 2 volts or greater intensify the trace while negative-going slopes of 2 volts extinguish the trace. Horizontal sweeps are generated internally at 5 to 50,000/sec. External sweeps may also be supplied with full-scale deflection produced by 300 mv. Step voltages having amplitudes from 600 mv to 30 volts with rise times up to 0.07 μsec produce a full-scale vertical raster. (Waterman Products Co., Inc., Dept. Sci650, 2445 Emerald St., Philadelphia 25, Pa.)

■ pH METER is a direct-reading instrument incorporating both a 0-to-14 pH scale and an expanded scale with 2.0 pH full-scale graduated in 0.1 pH units. Any 2-pH span can be selected for full-scale expansion. pH measurements are said to be accurate to $\pm$0.003 pH. Millivolt readings may be obtained over any 200-mv span from 0 to 1400 mv with accuracy said to be $\pm$2 mv and repeatability $\pm$0.3 mv. (Beckman Scientific and Process Instruments Division, Dept. Sci643, 2500 Fullerton Rd., Fullerton, Calif.)

■ TIMING SYSTEM includes a crystal- and oven-controlled frequency standard; a frequency divider which furnishes 60 cy/sec; a stroboscope on whose scale WWV signals appear visually for correction to WWV time; a power amplifier to boost the 60 cy/sec signal to 15 watts; a clock and photocell-gated programmer that provides 10-sec, 1-min, 30-min, and 1-hr timing pulses; and a control unit that provides for aural monitoring of signals. Accuracy is said to be within $\pm$0.1 sec/wk. Operating power is provided by 24-volt batteries. (Geotechnical Corp., Dept. Sci651, P.O. Box 28277, Dallas 28, Tex.)

■ NITROGEN ANALYZER performs automatically the micro-Dumas method of analysis. The operator is required only to prepare, weigh, and insert a sample-packed combustion tube, and adjust and read a counter indicating nitrogen volume. Determinations at levels as low as 0.01 percent are said to be possible with results within $\pm$0.15 percent of theoretical for routine materials.

Flexible combustion cycles are said to accommodate an almost unlimited variety of organic nitrogen compounds, including heterocyclic nitrogen. Determinations are performed at the rate of four to five per hour. (Coleman Instruments Inc., Dept. Sci654, Maywood, Ill.)

■ ROTARY TUBE ELECTRIC FURNACE is designed for continuous-flow calcining or sintering of ceramic and metal powders. The impervious mullite tube used is adjustable in rotational rate from 0 to 6 rev/min. Hot-zone length is 36 in. and diameter is 4⅛ in. Tilt is adjustable from 0 to 5 in. Operating temperatures up to 2500°F are attainable. Heaters are silicon carbide. (Pereny Equipment Co., Inc., Dept. Sci648, Columbus, Ohio)

■ TRANSFER VOLT-AMMETER measures a-c voltage and current between 5 cy and 50 kcy/sec with accuracy said to be within ±0.05 percent. Full-scale voltage ranges from 0.5 to 300 volts and full-scale current ranges from 7.5 ma to 5.0 amp are covered in two models. Operating principle is the comparison of heating effects of an unknown alternating current with an adjusted direct current and measurement of the latter with a null potentiometer. Internal mercury cells provide the d-c source. (Engelhard Industries, Inc., Dept. Sci659, 113 Astor St., Newark, N.J.)

■ POWER ISOLATOR provides up to 300 v-amp output at 115 volts a-c isolated from line voltage and line ground. A shielded transformer and a feedback isolation circuit are used. Loading of the output to ground is less than 2 pf capacitance and greater than 50,000 megohms. The device is portable and measures 12 by 11 by 6 in. (Moeller Instrument Co., Inc., Dept. Sci660, Richmond Hill 18, N.Y.)

■ TAPE SIMULATOR provides manual entry of data into punched tape systems. The device has a capacity of 80 bits of information, each entered by a pushbutton on the instrument's panel. Arrangement of the buttons in ten lines of eight channels coincides with eight-channel punched-tape code. Pushbuttons light up when depressed. The simulator substitutes for a tape reader for performing check-out and verification functions or may act as an auxiliary signal source. (Hallamore Electronics Co., Dept. Sci655, 714 N. Brookhurst St., Anaheim, Calif.)

■ DATA TRANSFER SYSTEM ultilizes digital techniques for long-distance point-to-point or party-line transfer of analog voltage data over voice-quality transmission circuits. The standard system

provides for transmission of up to three channels of analog information with accuracy said to be ±0.05 percent of full range and resolution of 0.006 percent of full scale at data sampling rates of ten per second in each channel. A wide range of signal levels is accommodated in addition to the standard ±10 volts. Parity checking and identification of data source is permitted. (Vitro Laboratories, Dept. Sci657, 200 Pleasant Valley Way, West Orange, N.J.)

▪ RATE TURNTABLE is a portable test unit for mounting rate gyros, antennas, guidance assemblies, and other components requiring imposition of constant rate of turn for performance checking. The basic unit provides a single rate about a vertical axis; modified units provide multiple rates, tilting to polar or horizontal axes, or servo drive. (Sterling Precision Corp., Dept. Sci656, 17 Matinecock Ave., Port Washington, N.Y.)

▪ PHASE AND RATIO METER provides simultaneous readings of phase angle and amplitude ratio between two radio-frequency signals. Frequency response is 150 kcy to over 100 Mcy/sec, and threshold sensitivity is 50 mv. The instrument combines a frequency converter with the manufacturer's type 405 phase meter. The converter, used with an external oscillator, converts two radio-frequency signals into audio signals of identical phase relationship and proportional amplitude. Outputs are provided for input to recorders. (Ad-Yu Electronics Lab, Dept. Sci666, 249-59 Terhune Ave., Passaic, N.J.)

▪ COUNTER-TIMER, fully transistorized, provides measurement of frequency from 0 to 10 Mcy/sec, time interval and period from 0.3 μsec to 10^8 seconds, frequency ratio to 10^7, and phase to 0.1 deg. Readout is by means of in-line electrode tubes. Three d-c amplifiers have 1-megohm input impedance and 0.1-volt r.m.s. sensitivity. Power consumption is 50 watts. (Systron Corp., Dept. Sci661, 950 Galindo St., Concord, Calif.)

▪ FLUOROMETER is basically an optical bridge that measures the difference between light emitted by a sample and that from a calibrated light path. A single multiplier phototube within a mechanical light interruptor samples the two light beams and provides an output signal whose phase depends on which of the beams is the stronger. This signal is used to effect balancing of the two beams by means of a cam. About 5 parts of quinine sulfate per billion provides full-scale deflection on the most sensitive range. Linearity is said to be 1 percent and readability 0.5 percent or

better. The instrument may be used as a nephelometer to resolve as little as 0.01 parts of silica per million. (Arthur H. Thomas Co., Dept. Sci674, P.O. Box 779, Philadelphia 5, Pa.)

■ SWEEP-SIGNAL OSCILLATOR furnishes output frequencies from 800 to 1400 Mcy/sec. Output power is 10 mw and output impedance 50 ohms. Output power is held flat within ±1 db over the entire range by a leveler circuit. Sweep operates as 30 cy/sec. Manual tuning over the entire range is also provided. (CGS Laboratories, Inc., Dept. Sci672, Wilton, Conn.)

■ SPECTROPHOTOMETER for the ultraviolet and visible ranges is a fully automatic, double-beam grating instrument. The monochromator incorporates two diffraction gratings, each with 1200 grooves per millimeter. Absorption spectra, reflectance spectra, and emission spectra can be recorded. A single lever positions a hydrogen, tungsten, or mercury lamp for rapid scanning of the ultraviolet spectrum without a break in the record. Speed of wavelength scan is automatically adjusted to the complexity of the spectrum being scanned. (Bausch and Lomb Optical Co., Dept. Sci670, Rochester 2, N.Y.)

■ ELECTRONIC FLASH for high-speed photography delivers a single flash whose duration is controllable to correspond with the writing rate of the camera. Wave form is square with rise and decay times of the order or 40 μsec. Duration settings are 8.7, 11.15, 14.75, and 22.25 msec. (Beckman and Whitley, Dept. Sci673, San Carlos, Calif.)

■ POLAROGRAPHIC INSTRUMENT for process monitoring performs automatic repetitive sampling, analytical pretreatment, and polarographic analysis of liquid from either of two sources, and records the results on a continuous strip chart. Sample and reagent are mixed by a stream of electrolytic hydrogen generated externally. Pretreatment unit and polarographic unit are each housed in steel cabinets and electrically interconnected. The pretreatment unit incorporates automatic pipettes for samples and reagents, polarographic cell, hydrogen inlet valve, mercury receiver, automatic sequence control circuit, power supply, and control panel. Over-all accuracy is said to be ± 5 percent or better. (Baird & Tatlock, London, Ltd., Dept. Sci653, Chadwell Heath, Essex, England)

■ DIAGNOSTIC AUDIOMETER uses a photocell to interrupt tone signals. Interruption is said to be free of accompanying clicks or pings and free of give-away hand motions, a slight movement of the finger being sufficient to start or stop the signal. Frequency range is 125 to 8000 cy/sec. Weight with accessories is 13 lb. (Acousticon International, Dictograph Products Inc., Dept. Sci662, Jamaica, N.Y.)

■ OSCILLOSCOPE DOLLIES provide a 20-deg viewing angle. Storage areas are provided for preamplifers, and a drawer for accessories. A rubber gasket prevents damage to instruments while installing or removing. Casters are 5 in. in diameter, rubber tired and ball bearing. Three power outputs and one input are included. (PBR Manufacturing Co., Dept. Sci663, 861 E. Luzerne St., Philadelphia 24, Pa.)

■ VOLTAGE-TO-FREQUENCY CONVERTER develops a frequency proportional to input voltage with long-term accuracy said to be within ±0.1 percent. Frequency range is 0 to 100 kcy/sec. Full-scale range can be switched from 0.1 volt through 1000 volts in five steps. Input polarity is automatically indicated. Models are available for rack, module, or cabinet mounting. (Vidar Corp., Dept. Sci664, 2107 El Camino Real, Palo Alto, Calif.)

JOSHUA STERN
National Bureau of Standards, Washington, D.C.

Letters

Artificial Biosphere

It is unfortunate that Dyson's suggestion [*Science* **131**, 1667 (1960)] as to how intelligent beings might survive after reaching "the limits set by Malthusian principles" does not do justice to the intelligence of these beings by explaining how they would overcome some of the obstacles which, at first sight, would seem to militate against their curious way of life.

Dyson's report describes a uniformly thick shell of fluid with a thickness of a meter or two and a radius twice the earth's distance from the sun. The shell is said to revolve about the central star, which implies that the material revolves as a whole. Presumably the material of the shell must be enclosed on both surfaces by transparent plastic sheaths of similar constructions, for self-gravitation cannot be expected to make the material cohere. However it is not conceivable that it would be possible to quarry from the material of a planet like Jupiter sufficient structural steel to keep the shell rigid against the shear forces and those that would tend to move material towards the equatorial plane.

Therefore, it must be assumed that radiation pressure must play a part in supporting the shell, so that its form will be that of an oblate spheroid rather than a sphere. For example, material at the poles of revolution of the shell would be supported entirely by radiation pressure, so that the polar radius of the shell would necessarily be less than the equatorial radius. However, a cursory calculation will show that this would be possible only at a distance from the central star comparable to but less than the radius of the sun.

Beings of lesser intelligence, not having discovered the appropriate laws of physics, might therefore seek some other distribution of their dismantled Jupiter that would have more intrinsic stability—for example, a torus lying in a plane perpendicular to the axis of its own rotation. The mass of Jupiter distributed in this way would yield a torus whose cross-sectional area was comparable with that of the moon, but unfortunately the flux of stellar radiation would be reduced by a factor of 10^6.

With conventional laws of physics, however, as Laplace was the first to show, even this arrangement would not be stable, and it is to be expected that the material of the torus would coalesce into one or more planetary objects. This suggests that, in the present state of intelligence, the dispersal of Jupiter into a thin shell about the sun would

not be an effective means of escaping the consequences of continued population growth but that it might be an experiment with an important bearing on various theories of the origin of the solar system. It would, for example, be interesting to see whether the outcome of the experiment was the recreation of Jupiter or the creation of a number of asteroids.

Another point is that a search for infrared stars would be valuable even in conventional science for the light it might throw on the evolution of stars which are very young or very small as compared with the sun.

JOHN MADDOX

Washington Post,
Washington, D.C.

Freeman Dyson's report suggesting that intelligent life elsewhere in the universe may be detected by looking for sources of infrared radiation was delightful. However, as an old science-fiction hand, I feel obliged to sound a cautionary note to the scientists. Or am I merely too dense to recognize a satire?

The basis of Dyson's argument is that an industrial culture may eventually occupy an artificial biosphere completely surrounding its sun, thus maximizing the territory and energy available for population expansion "to the limits set by Malthusian principles." The mass of Jupiter could be converted into an inhabited "spherical shell revolving around the sun at twice the Earth's distance from it," utilizing incident solar radiation which would be reradiated into space in the 10-micron band.

Offhand, I should think rotational and gravitational stresses alone would rule out such a structure of such dimensions. But since it is admittedly dangerous to assert that anything is impossible, I shall confine myself to questions of economics. Even Dyson intimates that the project would take several thousand years to complete; he calculates the energy required as equal to the sun's total output for eight centuries, and one does have to eat meanwhile. And meanwhile, too, the population growth necessitating this project will presumably continue. As Hauser remarks in the same issue [*Science* **131**, 1642 (1960)], at our present-day rate of increase we would reach "a population of one person per square foot of the land surface of the earth in less than 800 years." Thus, the economic surplus needed for the biosphere project would be consumed long before the latter got well started.

If we assume a ratio of population increase to industrial expansion low enough so that this contretemps does not occur, we must ask ourselves how

any intelligent species could be induced patiently to continue this enormous task, millennium after millennium. True, our human history contains epochs of grandiose and useless construction, such as the pyramid building of Egypt, but they never lasted very long. Any revolutionist who promised relief from the crushing burden of the biosphere project would be well received! He could doubtless get support for some or other population-control program; those who demurred would be martyred by exasperated taxpayers, or the equivalent thereof.

Of course, the entire species *might*, by advanced psychological techniques, be conditioned into such an antlike state that its government could never be overthrown, or break down from internal stresses, or evolve into something new. But given subjects as meek as this, and no reason to breed vast armies (for only a well-established world government could seriously entertain these ideas in the first place), the masters could regulate birth and death by fiat. Thus, the population would be stabilized at some rational figure and projects such as Dyson's would never be indicated.

In short, uncontrolled population growth will make the construction of artificial biospheres impossible, and control will make them unnecessary. So astronomical discovery of infrared sources won't prove anything about the inhabitants of other planets.

POUL ANDERSON

3 Las Palomas Road, Orinda, California

The suggestion by Freeman J. Dyson for investigating solar far-infrared radiation as one way to detect extraterrestrial intelligence sounds quite practical and sensible.

This leads me to suspect that if Dyson's assumption is correct—that intelligent beings exist of a far higher order of technological achievement than our own—it would be well-nigh impossible for such beings *not* to have detected us.

EUGENE A. SLOANE

"Air Engineering," Detroit, Michigan

In reply to Maddox, Anderson, and Sloane, I would like only to add the following points, which were omitted from my earlier communication.

1) A solid shell or ring surrounding a star is mechanically impossible. The form of "biosphere" which I envisaged consists of a loose collection or swarm of objects traveling on independent orbits around the star. The size and shape of the individual objects would be chosen to suit the convenience of the inhabitants. I did not indulge in speculations concerning the constructional details of the biosphere, since the ex-

pected emission of infrared radiation is independent of such details.

2) It is a question of taste whether one believes that a stabilization of population and industry is more likely to occur close to the Malthusian limit or far below that limit. My personal belief is that only a rigid "police state" would be likely to stablize itself far below the Malthusian limit. I consider that an open society would be likely to expand by a proliferation of "city-states" each pursuing an independent orbit in space. Such an expansion need not be planned or dictatorially imposed; unless it were forcibly stopped it would result in the gradual emergence of an artificial biosphere of the kind I have suggested. This argument is admittedly anthropomorphic, and I present it in full knowledge that the concepts of "police state" and "open society" are probably meaningless outside our own species.

3) The discovery of an intense point source of infrared radiation would not by itself imply that extraterrestrial intelligence had been found. On the contrary, one of the strongest reasons for conducting a search for such sources is that many new types of natural astronomical objects might be discovered.

FREEMAN J. DYSON
Institute for Advanced Study, Princeton, New Jersey

Hazards and Insecticides

Philip R. White states [*Science* **131**, 614 (26 Feb. 1960)] that "the problem" is much wider than "poisoned cranberries," chickens, and so on; that "the problem" is a "premature or inadequately prepared commercialization of scientific finding." White fortifies his opinion with a few cases, stating that these must be only a few of hundreds. White has presented only one side of the coin. That certain cases do represent a very dangerous trend is true, but the reverse side of the coin may be equally dangerous.

Pray let me, like White, cite a few examples. In the last few years this laboratory has tested two chemicals that came to us from Europe, highly recommended. In both cases we found the materials ineffective although not in any way dangerous. One of these was already on the market in Europe but was withdrawn because our work proved it ineffective. This case parallels the case of the French weed killers cited by White.

In the 1930's *Anopheles gambiae* was rampant in the valley of Rio Grande do Norte in northeastern Brazil. Many scientists (altogether too many) stated dogmatically that it was impossible to eradicate these mosquitoes, that the misery, sickness, social disorders, and death visited upon Rio Grande do Norte were inevitable for the Western Hemisphere from Buenos Aires to Galveston. Fortunately a small group of scientists supported by the Rockefeller Foundation and the Brazilian Government staked their honor and reputations, but not their lives, in a scientific Thermopylae. They used the tools available—namely, pyrethrum of evanescent efficacy and paris green of extremely high toxicity. In 2 years morbidity cases among the field workers numbered 595. Compare this with statistics for the village of Caicó (some 600 inhabitants), where there were 64 fatalities in the month of May 1959 as a direct result of invasion by *Anopheles gambiae. Anopheles gambiae* was eradicated in the Western Hemisphere, although the only weapons available were ineffective or hazardous by present scientific standards. The incident is forgotten, although it has been fully published and the report is readily available for anyone's perusal [F. L. Soper and B. Wilson, *Anopheles gambiae in Brazil* (Rockefeller Foundation)].

Today in the northeastern United States the dairy industry is confronted

with a new and dangerous pest—namely, *Musca autumnalis* or face fly. This insect is very closely related to the house fly, but it differs in habits. It congregates on the face of cattle, and these miserable animals have no defense. Like its close relative the house fly, it is an extremely effective transmitter of certain disease organisms, such as staphylococci, salmonellae, coliforms, and other enteric bacteria. It even likes the face of man, particularly the corners of the lips. For two summers I have watched this pest on the cattle pastured almost in my back yard. They are miserable animals with sore eyes, and I do not for one minute suppose that their milk is of the highest or most nutritious quality. We have available insecticides which are safe by any reasonable standards, and effective. However, they may not be used legally on dairy cattle because of the fanatical attitude of certain federal officials. The face fly is spreading steadily in the northeastern United States, where nothing is done to control or to eliminate this disease-bearing pest. I wish to point out that this is a very dangerous trend. We are accepting an obvious and well-proved hazard because certain individuals with legal power dream of a possible hazard connected with the use of insecticides upon dairy cattle. We grant that certain insecticides can be dangerous, but there are available today effective drugs that are not hazardous from the scientific point of view. They have been very well studied, and while they cannot be declared absolutely innocent (the absolute has no place in science) they are, when used as insecticides, as innocent as sugar, salt, or milk itself. This is all that a relative science can do, for science can never be absolute.

White's complaint, that insecticides used to control the fire ant are hazardous to wildlife, is out of proper reference. If permitted to spread throughout the southern United States, this pest species will destroy many wild species and their habitats. D. Hey, writing of Cape Providence, Union of South Africa, states, "particularly introduced forms such as the Argentine Ant" have played their part in depletion of wildlife. Evidence of the same "depletion" is recorded for the United States. We should not trade temporary loss of a few species over a small area for permanent loss of many types over a much larger area.

As Francis Bacon stated years ago, we must be willing to accept new remedies, or we must prepare ourselves for new ills. The fire ant and the face fly are merely two of the many ills that presently affect us. I know of many more. They happen to be new to this part of the world, but there are old as well as new problems. These are scientific problems and they must be dealt with by scientific methods. This means that we must open our minds to the relative laws of science and bar therefrom the absolute nonsense that has created the cranberry scandal and is driving us toward a dairy debacle. Every new drug should be adequately tested by the relative laws of science in general and of biology in particular. The use of absolute dicta, of the philosophical zero, such as White seems to approve, will prove disastrous again as in the past. Science can never prove absolute safety—it can prove necessity and relative safety.

Generalization from such limited cases is of uncertain value; the conclusion that the problem is fundamentally biological seems unavoidable. Consequently, the solution must follow the laws of biological science. The virulent poisons produced by staphylococci and other pathogens are a part of the problem. Dogmatic regulations that contravene the laws of biology will prove dangerous and even disastrous. Safety must be defined in terms of biology and not in terms of a philosophical zero, an absolute mathematical formula, or an analytical procedure.

PAUL D. HARWOOD
Hess and Clark, Ashland, Ohio

Electronic Brains?

A few years ago the new electronic digital computing machines were often popularly referred to as electronic brains. However, this practice soon fell into disrepute among scientists and engineers. A cliché which developed said in effect, "A general-purpose digital computer is designed to carry out arith-

metic operations in a predetermined sequence and could never think in any sense of the word." This cliché still represents the dominant attitude of many scientific and engineering publications on both sides of the iron curtain. An elaboration, which often follows the cliché, explains that the sequence of arithmetic and logical operations is completely predetermined by a human programmer, and any appearance of thinking by the computer is merely a manifestation of the thinking of the human programmer. (The general-purpose digital computers do carry out sequences of arithmetic and logical operations as specified by the programmer, but the programmer may specify that the sequence shall vary as a function of the input variable [or sensory] data.)

These projections of their own ignorance by pseudo experts may be amusing to researchers who are daily engaged in mechanized-thinking experiments on general-purpose and special-purpose computers. However, a scientist seeking employment or approval for a new project from a director of a research laboratory may not find these negativistic attitudes at all amusing. Such negativistic statements are almost invariably followed by a challenge to demonstrate the mechanized-thinking process by deriving the general theory of relativity. This seems comparable to requiring the Wright brothers to prove that they could fly by flying nonstop around the world.

It may seem improbable that research directors would be so ill informed concerning subjects relevant to their work. However, this seems to be the rule rather than the exception. It would appear that prominent scientists and engineers should be more cautious about asserting that certain things cannot be done merely because they do not know, at the moment, of any feasible method. They not only leave themselves open to ridicule in many instances but may also hinder the progress of research, for the direction of scientific research may be greatly affected by a simple, negativistic, dogmatic, cliché.

ROGER A. MACGOWAN
Army Ballistic Missile Agency, Redstone Arsenal, Huntsville, Alabama

Conversions

Apropos the editorial on "Metric versus English units" [*Science* **131**, 195 (22 Jan. 1960)] with its implications regarding conversions, I should like to call your attention to the reports on the Tiros [*Science* **131**, 1031 (8 Apr. 1960)] and U.S.S.R. "space ship" [*Science* **131**, 1510 (20 May 1960)] satellite launchings.

Apogee and perigee of the Tiros are given as 407.2 and 378.7 nautical miles, respectively. According to my conversion tables, 1 nautical mile equals 1.1516 statute miles. The corresponding apogee and perigee should be 468.9 and 436.1 statute miles. In the article they are given as 468.28 and 435.5 statute miles, corresponding to a conversion factor of 1.1500 statute miles per nautical mile.

Similarly, the announced weight of the Russian "space ship" was 4 tons, 540 kg. In the *Science* article this is given as 9988 pounds, corresponding to a conversion factor of 2.2000 lb/kg. In fact, the conversion is 2.2046; the weight in English units is apparently 10,009 lb.

For the purposes of the articles in *Science*, accuracy in these details is probably not important. Nevertheless, there is a lesson to be learned about the simplicity of conversions within the metric system and about the retention of significant figures during and after conversions.

PEMBROKE J. HART
IGY World Data Center A, National Academy of Sciences–National Research Council, Washington, D.C.

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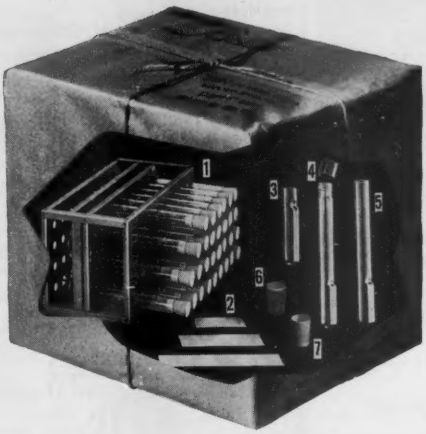

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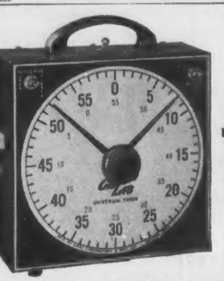

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